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U.S. COMPUTER RESEARCH NETWORKS:

CURRENT AND FUTURE

EXECUTIVE SUMMARY

PREPARED FOR:

NASA Lewis Research Center

Contract No. NAS3-25083, Task Order 2

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PREFACE

This document presents a summary of the report which was prepared by Contel Federal Systems for the NASA Lewis Research Center under Task Order 2 of the Contract NAS3-25083. Under this contract, Contel Federal Systems provides technical support to NASA for the assessment of the future market for satellite communications services. Task Order 1 focused on the costs and tariffs for telecommunications services. Task Order 2, the results of which are summarized in this Executive Summary, focused on the current and future telecommunications requirements of the United States research community.

ACKNOWLEDGEMENTS

The authors would like to thank members of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), members of the Federal Research Internet Coordinating Committee (FRICC), and other Federal agency representatives who provided information on their networks. Special thanks are due to EDUCOM representatives, directors and managers of the various computer research networks, and the staff of the Corporation for National Research Initiatives for their cooperation. These individuals and other government, industry and academic leaders provided much needed information and valuable insights for this study.

Special thanks are due also to the NASA Lewis Research Center and the technical officer of this study, Mr. James E. Hollansworth, for providing direction and guidance for this study.

SUMMARY

During the last decade, the Government Networks Division of Contel Federal Systems has assisted NASA in conducting a series of telecommunications forecasting studies to project trends and requirements, and to identify critical telecommunications technologies that must be developed to meet future requirements. The current study builds upon earlier efforts, and estimates the U.S.'s current and future needs for research and development (R&D) telecommunications networks.

NASA is concerned that the future telecommunications capacity requirements of the U.S. R&D community are not being factored in the national level planning of communications resources. There are two problems. One, will there be adequate capacity to meet the projected requirements of the U.S. R&D community in the years 2000 or 2010? Given the long gap between conception and implementation, it is imperative that the requirements be assessed now and the means to satisfy the requirements be identified now. Two, what are the cost savings associated with implementation of an integrated research network (IRN) compared with several interconnected networks, owned and operated by a number of entities, as is the case today. This study projects the capacity requirements, and shows that substantial cost savings can be realized by implementing an integrated network, rather than several smaller interconnected networks.

Four major tasks were performed to develop estimates of communications requirements of the U.S. R&D community. First, federal agencies' current research communications networks were identified, defined and described. Second, an integrated research network (IRN) designed to meet the combined current requirements of all research networks was sized. Third, given this definition of the Current IRN and the results of an analysis of projected events and trends, Future IRNs (i.e., for 1991, 1996, 2000 & 2010) designed to meet the combined future requirements of all research networks were sized. Fourth, based on these definitions of Current and Future IRNs, the costs of the Current and Future IRNs were estimated.

It should be noted that this study is limited to domestic requirements. It does not factor in additional capacity requirements generated by ever-increasing international cooperative resarch efforts. Also, for the purpose of this study, a network's installed capacity was used as a measure of its traffic. Estimates of traffic loads or of peak hour traffic were not available for most of the networks included in this study.

The major networks selected for this study were, by agency: DoD (Advanced Research Agency Proejcts Network-ARPANET, Defense Research Internet); NSF (NSFNET---Backbone, 21 mid-level and over 250 campus networks); NASA (NASA Science Network, Space Physics Analysis Network, Numerical Aerodynamics Simulation Network, NASA Communications); DOE (Energy Science Network, Magnetic Fusion Energy Network, High Energy Physics Network, LEP3NET, OPMODEL); Other (BITNET, CSNET).

The Current (1989) IRN was estimated to have 40 major access points and a T1 backbone with 187 T1 links. In 1991, the major access points and connectivity were projected to be the same, but much of the 1991 IRN backbone was projected to have T3 capacity. In 1996, ten new major access points were added, and link capacities were increased as follows: some 1991 T3 links were increased to 1 gigabits per second (Gbps) links; some 1991 T3 links were increased to 564/274 megabits per second (Mbps) links; all 1991 T1 links were increased to 564/274 Mbps links; and all new access points were connected by either 90 or 45 Mbps links.

In 2000, major access points and connectivity were projected to be the same as for 1996, but link capacities were increased as follows: all 1996 1 Gbps links were increased to 5 Gbps links; all 1996 564/274 Mbps links were increased to 1 Gbps links; and all 1996 90/45 Mbps links were increased to 564/274 Mbps links. Similarly, in 2010, major access points and connectivity were projected to be the same as for 2000, but link capacities were increased as follows: all 2000 5 Gbps links were increased to 25 Gbps links; all 2000 1 Gbps links were increased to 5 Gbps links; and all 2000 564/274 Mbps links were increased to 1 Gbps links.

While the IRN capacity was projected to increase by about a factor of 1800, from 1989 to 2010, monthly circuit costs of the IRN were projected to

increase by only about a factor of 20. The implications of not fully integrating the IRN in 1996 and beyond were found to be significant. In 1996, the monthly cost of an IRN that is not fully integrated was projected to be about double the cost of a fully integrated IRN. In 2000, it was projected to be about triple the cost. In 1996, the fully integrated IRN monthly circuit costs were estimated to be about five million dollars less than the non-fully integrated IRN costs. This difference increases to about sixty million dollars per month in 2010. Exhibit ES-25 on page ES-55 presents a summary of the IRN cost projections.

Major findings of this study are summarized in Section 3 of this report. A more comprehensive report which includes data on major networks is also available.

RECOMMENDATIONS

A consensus of academic, industry, and institutional experts engaged in developing and operating computer research networks is that significantly higher communications capacities will be needed in the years to come to link researchers to enable them to collaborate in cooperative research endeavors regardless of their physical locations. The researchers' needs for communications will encompass accessing large data bases, linking supercomputers in a massively paralleled configuration, and presenting simulation results with ever-increasing resolution and clarity to permit researcher to overcome resource limitations. From that perspective, communications could be viewed as enhancing the effectiveness of research facilities in the same manner as command, control and communications are viewed as force multipliers by the defense community.

NASA needs to address several technology and policy issues in order to translate today's vision into what some experts have called the "Collaboratory" of the future. Some specific recommendations are as follows:

1. Broaden the scope of the current study to include the communications requirements of ever-increasing international

cooperation among researchers.

- 2. Participate in standards setting committees to actively set the standards for door-to-door delivery of data at rates approaching gigabits and terabits per second.
- 3. Examine the current and future capacity plans of the commercial communications industry vis-a-vis researchers' needs, and identify communications assets such as satellites or terrestrial systems that are needed to meet researchers' unique requirements.
- 4. Identify technologies in the areas of computer networking, communications systems, and communications networks management that need to be developed to meet researchers' requirements in the year 1996 and beyond.
- 5. Identify policy issues that must be resolved to provide communications facilities to researchers in a most cost effective manner. The current approach of implementing several interconnected networks does not take advantage of economies of scale and does not place responsibility on a single organization to integrate requirements into a national level initiative.

SECTION 1

STUDY OVERVIEW AND BACKGROUND

1.1 STUDY OVERVIEW

During the last decade, the NASA Lewis Research Center's Communications Program has conducted a series of telecommunications forecasting studies to project communications trends and requirements, and to identify critical telecommunications technologies that must be developed to meet future requirements. The Government Networks Division of Contel Federal Systems has assisted NASA in these studies, and the current study builds upon these earlier efforts.

1.2 STUDY BACKGROUND

The current major thrust of the NASA Comunications Program is aimed at developing the high risk, advanced communications satellite and terminal technologies required to significantly increase the capacity of future communications systems. Also, major new technological, economic, and social-political events and trends are now shaping the communications industry of the future.

Therefore, a re-examination of future telecommunications needs and requirements is necessary to enable NASA to make management decisions in its Communications Program and to ensure that proper technologies and systems are addressed. This re-examination is being accomplished through a series of studies which are helping NASA define the likely communication service needs and requirements of the future, and thereby, ensuring that the most appropriate technology developments are pursued.

Previous studies have dealt with the costs and tariffs for telecommunications services. The current study, the results of which are summarized in this volume, focused on telecommunications requirements for the U.S. research and development community.

SECTION 2

METHODOLOGY

2.1 PURPOSE

The purpose of this study was to assist NASA in determining the U.S.'s current and future needs for research and development telecommunications networks. This understanding of network needs is helping NASA define the future technology requirements and thereby ensuring that the most appropriate technology developments are pursued.

2.2 TASKS

This study accomplished its purpose of determining current and future research communications needs by undertaking the following tasks:

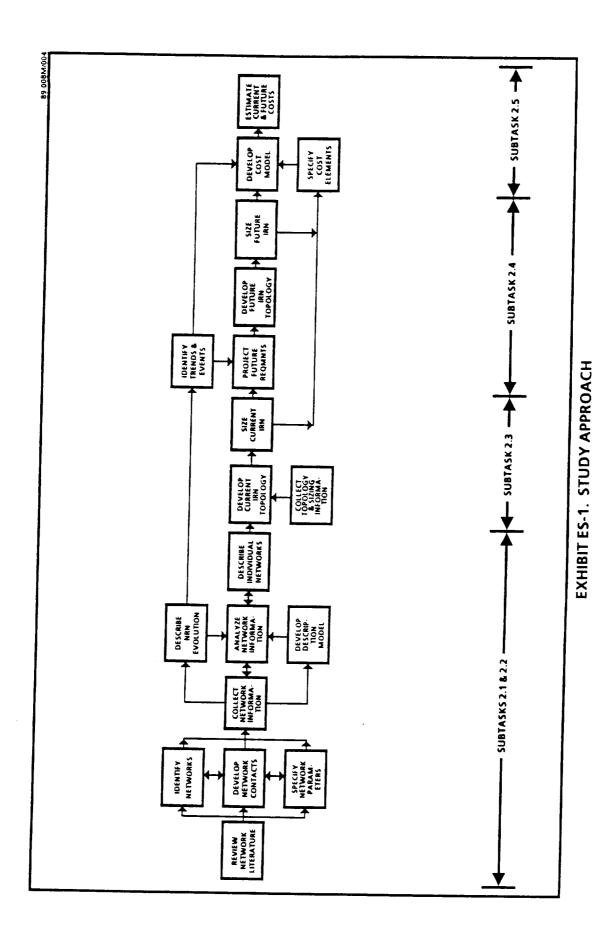
- 1. Identifying, defining and describing federal agencies' current research communications networks;
- 2. Sizing an integrated research network to meet the combined current requirements of all research networks;
- 3. Sizing an integrated research network to meet the combined future requirements of all research networks;
- 4. Estimating the costs of the current and future integrated research network.

2.3 APPROACH

To accomplish the purpose of this study, the study approach depicted in Exhibit ES-1 was used. This study approach will be summarized for each of the four major tasks listed above.

2.3.1 Identifying, Describing And Defining Networks

To identify, define and describe current computer research networks, Page ES-2



Page ES-3

a computer research network was defined, a model for describing such a network was developed, the evolution of a national research network was described, and networks were selected and described.

The following is the definition, developed for this study, of a computer research network. A computer network exists when independent computers are connected in some way that allows them to exchange information. For the purposes of this study, when such a network is used by scientists for scientific research purposes, it is designated as a computer research network. In a computer network, the computers can range in size from small microcomputers to supercomputers. These computers can be connected by a variety of media, such as optical fiber, microwave, copper, and/or satellites. The common conventions or rules that define how these computers communicate with each other are the communication protocols. Therefore, for the purpose of this study, a computer research network was defined as a communications network connecting a set of computers used by scientific researchers to exchange scientific data over a variety of communications media using common conventions or protocols.

Based on the definition presented above, a model for describing computer research networks (CRNs) was developed. This CRN model is outlined in Exhibit ES-2. The model includes descriptions of the following computer network topics: history; types; extent and size; computers, nodes and topologies; media; speed, throughput, and bandwidth; layers and protocols; services; uses; administration; and the future. The CRN model was used to describe the networks that were selected for comprehensive review.

An extensive amount of effort has been, and continues to be, devoted to the development of a conceptual National Research Network (NRN). The results of this effort were used to design and conduct the current study. Likewise, it is expected that the results of the current study will be helpful in the future planning of the NRN. To better understand this relationship between the current study and the development of an NRN, a summary of the activities underlying the development of an NRN and the organizations responsible for the NRN concept was developed.

EXHIBIT ES-2. MODEL FOR DESCRIBING NETWORKS

HISTORY

WHEN STARTED, IMPETUS, MAJOR CHANGES

TYPE OF NETWORK

NETWORK, INTERNET, METANETWORK

PURPOSES & SERVICES

WHY IT WAS DEVELOPED AND FOR WHOM, SERVICES OFFERED

EXTENT & SIZE

GEOGRAPHICAL COVERAGE, #NODES/HOSTS

TOPOLOGY

PICTURE - LOCATION & CONNECTIVITY OF NODES

COMPUTERS

PURPOSE AND SIZE OF COMPUTERS

MEDIA & LINK SPEEDS

TYPE OF MEDIA, SPEEDS IN BITS PER SECOND (BPS)

PROTOCOLS

NAME OF PROTOCOL SUITE (E.G., TCP/IP)

ADMINISTRATION

WHO - POLICY, OPERATION, INFORMATION

FUNDING

WHO PROVIDED SUPPORT

FUTURE

PLANS - TECHNOLOGICAL, POLITICAL

To identify the major computer research networks sponsored by the federal government, all major federal agencies were contacted. First, an initial list of federal agencies of interest was developed, and this list was reviewed to determine which agencies were most likely to have computer research networking requirements and/or interests. Based on this review, a second list was developed of agencies expected to have such requirements and/or interests. This list, which is presented in Exhibit ES-3, includes those agencies which were actually contacted.

Information on these federal agencies' networks was collected through telephone interviews, personal interviews and analysis of existing publications and reports. For each of the agencies contacted, the following information was collected: name, address, telephone number of agency contact person; and type of networks the agency uses (i.e., those managed by and/or funded by them and those that they merely access). Based on the information obtained from the federal agencies, a brief summary of the computer networks sponsored by and/or used by these agencies was developed. This information then was reviewed and analyzed. The majority of the agencies contacted have or use telecommunications networks for operational and administrative purposes. Most of these agencies do not have their own computer research network, but they usually have access to such networks when they need them.

Based on the review and analysis described above and on the information obtained when examining the evolution of the NRN, a perspective on scientific research and computer research networks was developed. This perspective is depicted in Exhibits ES-4 and ES-5. In Exhibit ES-4, research is divided into "activities on ground" and "activities in space," and in both instances, the activities can be either national or international. A single scientific research effort may involve any of the possible combinations of research activities, i.e., on ground, in space, national or international. The current effort has focused primarily on national (i.e., the United States) research activities on the ground and in space.

The types of United States computer research networks examined in this study are listed in Exhibit ES-5 and include various types of

EXHIBIT ES-3. FEDERAL AGENCIES CONTACTED

Agriculture, Dept. of

Commerce, Dept. of

National Institute of Standards & Technology (NIST)

National Telecommunications & Information Administration (NTIA)

National Oceanic & Atmospheric Administration (NOAA)

Defense, Dept. of

Defense Advanced Research Projects Agency (DARPA)

Defense Communications Agency (DCA)

Education, Dept. of

Energy, Dept. of

Environmental Protection Agency (EPA)

Health & Human Services, Dept of

National Institutes of Health

National Library of Medicine

Housing and Urban Development, Dept. of

Interior, Dept. of

U.S. Geological Survey

Bureau of Mines

Office of Surface Mining Reclamation

Fish & Wildlife Service

Minerals Management Service

Justice, Dept. of

Library of Congress

National Academy of Sciences

National Aeronautics & Space Administration

National Science Foundation

Nuclear Regulatory Commission

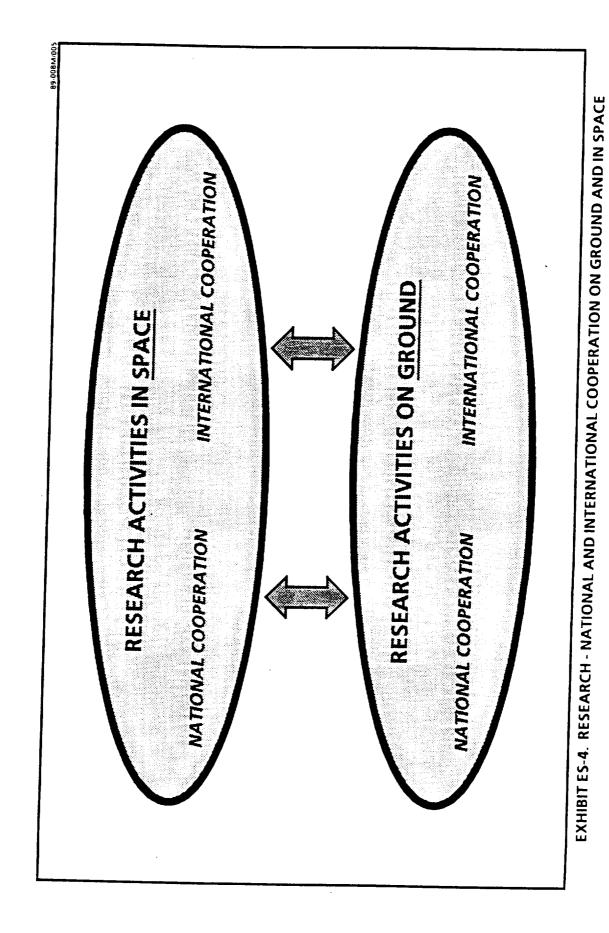
Transportation, Dept. of

U.S. Coast Guard

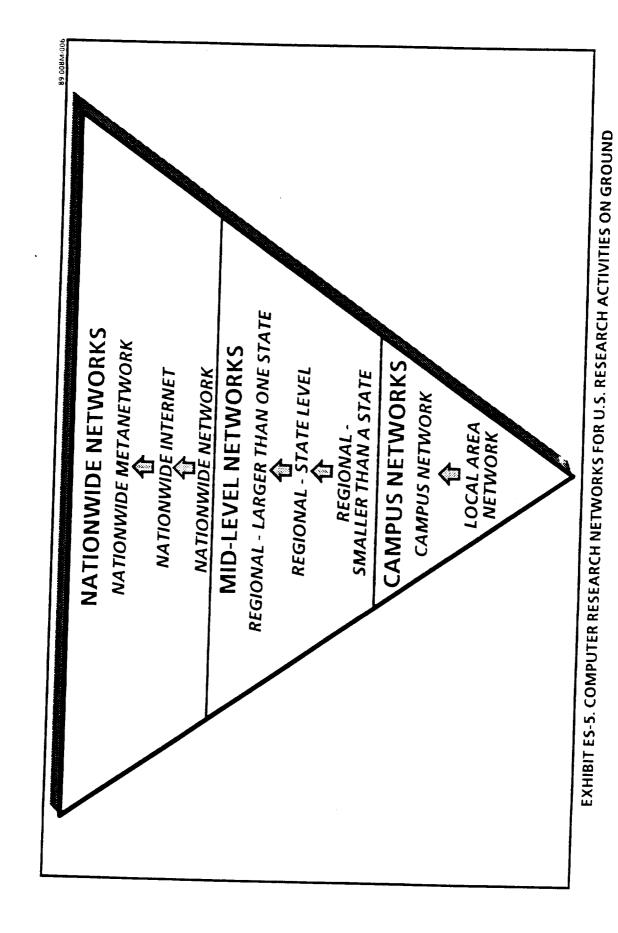
Federal Aviation Administration

Treasury, Dept. of the

Veteran's Administration



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nationwide, mid-level and campus area networks. An inverted triangle is used to depict the various sizes of networks and the relationship of smaller networks to larger ones. The adjectives "smaller" and "larger" are used here to denote geographical areas rather than capacities.

Based on the perspective described above, the results of the analysis of federal agencies' network use, and the information obtained when describing the evolution of the NRN, the networks selected for comprehensive examination in this study were identified. Then each of these networks were described using the CRN model presented in Exhibit ES-2. To develop these descriptions additional information was collected on each network through interviews and the review of network literature.

2.3.2 Sizing The Current Integrated Research Network

The comprehensive descriptions of the selected computer research networks then were used to develop the topology of an integrated research network (IRN) representing the aggregation of selected major current computer research networks, and to size the Current IRN.

The major activities conducted to size the Current IRN included: collecting current topology data, developing a network database, identifying major access points, determining major access point connectivity, determining the link capacity between major access points, and defining the Current IRN.

After the current topology information was collected and organized, a main network database was developed so that the network information could be analyzed when sizing the Current IRN. This database then was used to identify major access points. Common hubs and common routes were identified by noting where the various networks overlapped. Once these major access points were selected, their connectivity was determined by reorganizing the original main network database in terms of these major access points.

The database then was used to note how many links originated from each major access point, what their terminations were and what their

speeds were. This information then was used to specify the IRN backbone and the capacity requirements of the various segments of the backbone. The Current IRN then was defined in terms of this IRN backbone and link capacity.

2.3.3 Sizing The Future Integrated Research Network

Given the definition of the Current IRN, information on events and trends expected to impact future development of the IRN was collected and analyzed. Then the definition of the current IRN and the results of this analysis of events and trends were used to develop projections of the size of the IRN at future points in time.

The major activities conducted to size the Current IRN included: reviewing th literature on projections related to an IRN, identifying relevent events and trends, surveying experts in the field, analyzing results of the literature review and survey, specifying benchmark years, identifying new major access points, developing a future IRN database, projecting backbone link speeds and defining IRN for each benchmark year.

Previously collected literature (e.g., national reports, journal articles, and conference summaries) were reviewed to identify strategies for projecting, and actual projections of, the future requirements for an IRN. The results of this review suggested that a combination of qualitative and quantitative factors should be considered when projecting the future requirements for an IRN.

These qualitative and quantitative factors involved:

- 1. Network Needs And Usage i.e., the future needs of scientists, usage growth trends, and the addition of new groups of users.
- 2. <u>Network Development</u> i.e., the development of new networks and the reconfiguration of existing networks.
- 3. Federal Government Activity e.g., legislation and funding support.
- 4. <u>Private Telecommunications Company Activity</u> e.g., financial support and research and development participation.
- 5. NRN Plans e.g., FRICC, FCCSET and EDUCOM projections,
- 6. <u>Technological Changes</u> e.g., advances related to developing a Gbps

network.

7. <u>Economic Pressures</u> - e.g., international competition motivating both federal and private support for an IRN.

These factors were used to develop a brief guide for surveying leaders in the field of computer research networks. Some fifteen experts were asked to give their opinions, and the basis for them, of when and how a national computer research network might develop in the future. Then, the survey information and the initial literature review findings were analyzed, and the results of the anlysis were used to identify appropriate benchmark years, identify additional major access points, and project link speeds for the future IRNs.

Based on the analysis noted above the following guidelines were specified for projecting the future IRN:

- 1. Benchmark years would be: 1989 (Current), 1991, 1996, 2000, and 2010.
- 2. Major access points would be the same for 1989 and 1991; new major access points would be added in 1996 and traffic centers in 2000 and 2010 would be the same as for 1996.
- 3. For the sake of clarity, only the IRN backbone would be depicted for each benchmark year; while many non-major access points will be added yearly, these would not be presented in the projections.
- 4. Connectivity would be the same for 1989 and 1991; it also would be the same for 1996, 2000 and 2010 with new access points added for 1996.
- 5. The IRN link speeds would include DS1 (T1), DS3 (T3), DS4(T4), and Gbps speeds; several speeds would be used for each benchmark year; and the magnitude of speed increases would reflect technology/use projections.

Given these guidelines, the current network database was used to develop a new future network database, reflecting the changes in major access points, connectivity and link speeds, for each of the four future benchmark years. These databases then were used to develop the definitions of the IRN for four benchmark years.

2.3.4 Estimating Current And Future IRN Circuit Costs

Once the definitions of the current and future nationwide integrated

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computer research networks were developed, it was possible to estimate the current and future circuit costs of the IRN. The definitions of the IRN, along with current and future cost models and databases, were used to estimate circuit costs for each of the benchmark years.

The major activities conducted to size the Current IRN included: converting area code and exchange information to V & H coordinates; developing averaging costs per mile for various T1 links; developing a cost model for Current IRN costing; estimating circuit costs of the Current IRN; developing the 1991 IRN database; estimating the 1991 IRN circuit costs; developing a cost model for 1996, 2000 and 2010 IRN; and estimating circuit costs of the IRN for 1996, 2000 and 2010.

First, the approach used to estimate circuit costs for the various benchmark years was developed. The approach used to estimate Current IRN costs and the 1991 IRN costs was different from that used to estimate IRN costs for 1996, 2000 and 2010. The major reason for using different approaches is that it was assumed that in 1989 and 1991 the IRN would not be integrated from a cost point of view, but would be in 1996 and beyond. In 1989 and 1991 the trunking requirements for each of the selected networks were costed individually. For each of the benchmark years, 1996, 2000 and 2010, the trunking requirements of the total IRN were costed.

The first step in estimating Current IRN circuit costs was to determine the V (vertical) and H (horizontal) coordinates of each major access point. The V and H coordinates then were used to determine the mileage between any two of the access points. Next, a sample of the major access point area codes and exchanges were used to obtain real tariff data from the Network Analysis Center in Great Neck, New York for 56 Kbps and T1 services. This sample of real tariff data was used to develop the average circuit cost per mile for various link distances. It should be emphasized that these costs pertain to circuit costs and do not include costs associated with the end user interface equipment.

Given the mileage between any two access points on the Current IRN and the average cost per mile for various 56 Kbps and Tl links, a Current IRN cost database was developed. This cost database reflected the Current

IRN definition and included the Current IRN cost model that was based on current tariff costs and IRN link distances. The database then was used to calculate the current costs of each link on the IRN and the total cost for the entire Current IRN.

To estimate the circuit cost of the 1991 IRN, the Current IRN cost database and cost model were modified to reflect the 1991 IRN definition and the costs of T3 links. To estimate the costs of T3 links, it was assumed that carriers would cost future circuit offerings as they had in That is, the increase in cost, for example, from a DSO (64 Kbps) to a DS1 (1.544 Mbps), was used to estimate the increase in cost from DS1 to a DS3. The increase in cost from a DS0 to a DS1 which offers 24 times the capacity of a DSO has been about a factor of six. the ratio of capacity increase to cost increase is about four (i.e., 24/6 That is: New Cost = (Capacity Increase/4) X Lower Speed Cost. Therefore, the increase in cost from a T1 to a T3 which offers 28 times the capacity of a T1 would be about a factor of seven. Or, T3 Cost = (28/4) X T1 Cost. As calculated for the Current 1989 IRN, the estimated circuit costs of each network in the 1991 IRN and the total cost for the entire 1991 IRN were calculated.

To estimate the future IRN circuit costs for 1996, 2000 and 2010, new cost models and new cost databases were developed. For the new cost models, costs of higher speed links were estimated in the same manner as noted above for estimating the cost of T3 links from T1 link costs. Given these estimates of higher speed links, an IRN cost model was developed for each of the benchmark years of 1996, 2000 and 2010. An IRN cost database then was developed for each of these benchmark years using the definitions of the IRNs developed for each of these years and the estimated future circuit costs of the various link speeds and distances. Then, these cost databases were used to estimate the future IRN costs for 1996, 2000, and 2010.

SECTION 3

MAJOR FINDINGS

3.1 OVERVIEW

The major findings of this study are summarized below and focus on: the evolution of a national research network; the descriptions of the selected United States computer research networks; the Current IRN; the Future IRN; and estimates of current and future IRN circuit costs.

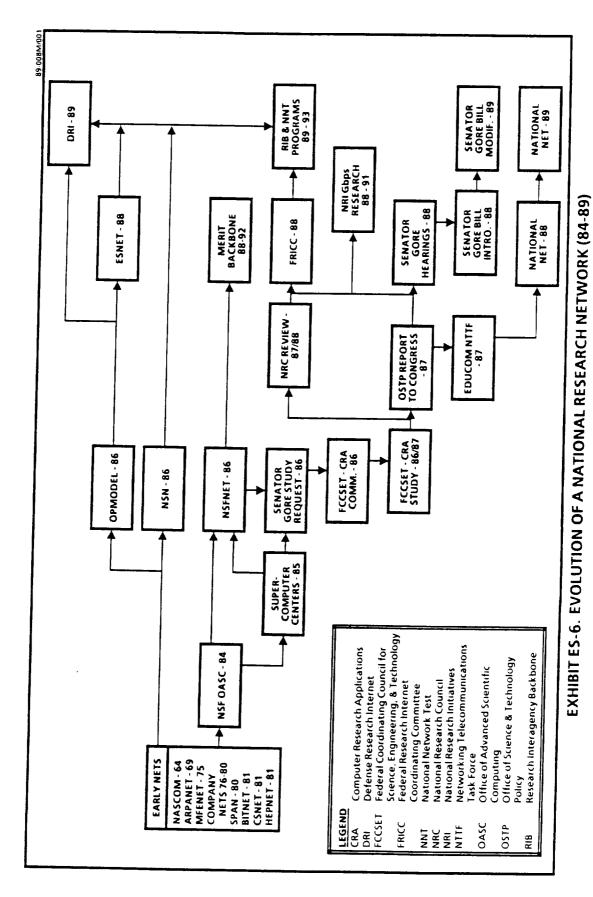
3.2 EVOLUTION OF A NATIONAL RESEARCH NETWORK (NRN)

The evolution of an NRN is diagrammed in Exhibit ES-6. The history of the NRN summarized in this exhibit covers the period of 1984 through the Spring of 1989 and focuses on the interrelationships between four groups of events: the development of major research networks; the pursuit of related legislative agenda; the formation of national-level committees and offices; and the performance of key national studies.

The results of this examination of the evolution of an NRN suggest that a number of key questions concerning an NRN remain to be answered. The key questions that remain to answered are listed below.

Key Questions

- What do we mean by <u>research</u>? Is it limited to a miniscule scientific community engaged in advancing frontiers of science, or does it include supporting engineering and development types of activities. While some have broadened research to include all of education, others expect an NRN to be more limited, especially in the near-term, in its application.
- 2. Who should <u>use</u> the network? Potential users range from the scientific researcher to the general public.



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- 3. Who should manage the network? Government? Academia? Not-for-profit organizations? Business/Industry? Or, some combination of these groups?
- 4. Who should pay for the network creation and operation? Suggestions range from treating the NRN as a government investment to a utility. Suggestions also have been made for basing payment on the stage of network development and on the user and usage.
- 5. What are the network <u>needs</u> and <u>requirements</u>? Will we really need to send giga bits per second (Gbps) traffic door-to-door, and if so, what requirements will this impose on the backbone network? If we need to send 1 Gbps door-to-door, will we need a backbone that supports data rates on the order of 10 to 100 Gbps?
- 6. How do we <u>transition</u> from where we are to where we need to be? What research and development steps must be taken? How do we ensure that all stakeholders are represented? What institutional changes are necessary?
- 7. What are the <u>international</u> implications? What are the implications of the sharing of ideas and resources on an international scale for our NRN requirements, our security, and our economic competitiveness? Should we work towards linking every scholar in the world with every other scholar?

3.3 DESCRIPTIONS OF SELECTED NETWORKS

Based on the information obtained when describing the evolution of the NRN, the results of the analysis of federal agencies' network use, and the perspective of scientific research and computer research networks, the following networks were selected for comprehensive examination in this study:

1. Department of Defense (DoD) research networks: Advanced Research Projects Agency (ARPANET), Defense Research Internet (DRI).

- National Science Foundation Network (NSFNET): three level network including a national backbone, twenty-one mid-level networks, and over 250 campus networks.
- National Aeronautics and Space Administration (NASA) networks: NASA
 Science Internet (NSI), NASA Science Network (NSN), Space Physics
 Analysis Network (SPAN), Numerical Aerodynamics Simulation Network
 (NASNET), and NASA Communications (NASCOM).
- 4. Department of Energy research networks: Energy Science Network (ESNET), Magnetic Fusion Energy Network (MFENET), High Energy Physics Network (HEPNET), LEP3NET (A Cern accelerator experiment network), and OPMODEL (An advanced satellite network).
- 5. BITNET (Before Its Time Network) and CSNET (Computer + Science Network). BITNET and CSNET were included because so many researchers and scientist (e.g., those at NIH) use these networks.

These selected networks (also listed in Exhibit ES-7) are national (i.e., United States) networks used for research activities on the ground and in space. As a group they serve researchers across the United States and have worldwide connections. Individually, these networks are in different states of development (i.e., from initial operation to being replaced), and vary, for example, in size, capacity, protocols and services. Each of these networks were comprehensively described using the CRN model presented earlier in Exhibit ES-2. The information on these comprehensively examined networks provided the data base for sizing a current and projecting a future composite integrated computer research network.

3.4 THE CURRENT INTEGRATED RESEARCH NETWORK (IRN)

The major findings obtained from the activities conducted to size the current integrated computer research network are presented in terms of the following: the major access points and their V & H coordinates; the Current IRN links; and the Current IRN topology.

EXHIBIT ES-7. NETWORKS SELECTED

1. Department of Defense (DOD) research networks:

Advanced Research Projects Agency Network (ARPANET)

Defense Research Internet (DRI)

2. National Science Foundation Network (NSFNET) - Three level network:

National backbone

Twenty-one mid-level networks

Thirteen Original Backbone and Regional Networks:

NORTHWESTNET, BARRNET, SDSCNET, WESTNET, USAN, MIDNET, SESQUINET, NCSNET, MERIT, PSCNET, NYSERNET, JVNCNET, SURANET.

Eight New Regional Network:

CERFNET, CICNET, LOS NETTOS, MRNET, NEARNET, OARNET, PREPNET, THENET.

Over 250 campus networks

3. National Aeronautics & Space Administration (NASA) research networks:

NASA Science Internet (NSI)

NASA Science Network (NSN)

Space Physics Analysis Network (SPAN)

Numerical Aerodynamics Simulation Network (NASNET)

NASA Communications (NASCOM)

4. Department of Energy (DOE) research networks:

Energy Science Network (ESNET)

Magnetic Fusion Energy Network (MFENET)

High Energy Physics Network (HEPNET)

LEP3NET (A Cern Accelerator Experiment Network)

OPMODEL

 BITNET (Before Its Time Network) and CSNET (Computer + Science Network)

3.4.1 Current IRN Major Access Points

The major access points for the Current IRN are listed with their state and V & H coordinates in Exhibit ES-8. These access points are: Albuquerque, Austin, Boston, Boulder, Chicago, Cleveland, Columbus, Dallas, Detroit, Houston, Huntsville, Indianapolis, Iowa City, Ithaca, Kansas City, Kennedy Space Center, Lincoln, Livermore, Los Angeles, Madison, Miama, Minneapolis, New York, Norfolk, Oak Ridge, Philadelphia, Pittsburgh, Portland, Princeton, Salt Lake City, San Diego, San Francisco, Seattle, Sate College, Tallahassee, Tucson, Urbana, Wallops Island, Washington, and White Sands.

3.4.2 Current IRN Links

The links between pairs of the major access points listed above and the capacity of these links are listed in Exhibit ES-9. For City A and City B the following information is presented: city ID (i.e., major access point name), city name, city state, and link speed (i.e., capacity).

3.4.3 Current IRN Topology

The Current IRN topology, based on these major access point links, is depicted in Exhibits ES-10. Exhibit ES-10 depicts the major access point T1 connectivity in the Current IRN. The numbers for the various links represent the number of T1s required for the various links. A total of 187 T1s were estimated to be required for the Current IRN.

3.5 THE FUTURE INTEGRATED RESEARCH NETWORK (IRN)

The major findings obtained from the activities conducted to size the future integrated computer research network are presented in terms of the IRN city A and city B links and capacities for the future benchmark years and the topology maps showing major access point connectivity for each of the future benchmark years.

====		=======		
KEY	CITY	STATE	V	Н
AB	ALBUQUERQUE	NM	8549	5887
AU	AUSTIN	TX	9005	3996
ВО	BOSTON	MA	4422	1249
BD	BOULDER	∞	7456	5961
CH	CHICAGO	IL	5986	3426
CL	CLEVELAND	OH	5574	2543
CB	COLUMBUS	OН	5972	2555
DL	DALLAS	TX	8436	4034
DT	DETROIT	MI	5536	2828
HU	HOUSTON	TX	8938	3536
HIN	HUNTSVILLE	AL	7267	2535
IN	INDIANAPOLIS	IN	6272	2992
IO	IOWA CITY	IA	6315	3971
IT	ITHACA	NY	4798	1990
KS	KANSAS CITY	MO	7249	4210
KN	KENNEDY SPC CTR	FL	7919	0880
LI	LINCOLN	NE	- 6823	4674
LL	LIVERMORE	CA	8504	8606
LA MD	LOS ANGELES	CA	9213	7878
MI	MADISON	WI	5890	3798
WID WIT	MAMI	FL	8351	0527
MP NY	MINNEAPOLIS	MN	5781	4525
NF	NEW YORK	NY	4997	1406
DR	NORFOLK	VA	5936	1198
OK PH	OAK RIDGE	IN	6811	2303
PT	PHILADELPHIA	PA	5251	1458
PO PO	PITTSBURGH PORTLAND	PA	5621	2185
PR	· — - · -	OR	6799	8914
SL	PRINCETON SALT LAKE	ŊJ	5120	1436
SD	SALI LAKE SAN DIEGO	ΩŢ	7576	7065
SF	SAN DIEGO SAN FRANCISCO	CA.	9468	7529
SE	SEATTLE	CA.	8492	8719
SC	STATE COLLEGE	WA	6336	8896
TL	TALLAHASEE	PA	5360	1933
īŪ	TUCSON	FL	7876	1715
IL	URBANA	AZ IL	9342	648C
WI	WALLOPS ISLAND	VA	6371	3336
DC	WASHINGTON	DC	5657	1249
WS	WHITE SANDS		5622	1583
	WATE OUMD	NM	9132	5742

EXHIBIT ES-8. Current IRN Major Access Points

CURRENT IRN TRAFFIC LINKS - SORT CITY - A ID

ID	CITY - A	ST	ID	CITY - B	ST	CAPACITY
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA	56
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA.	1544
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA	56
AB	LOS ALAMOS	NM	AU	AUSTIN	TX	56
AB	LOS ALAMOS	NM	KS	LAWRENCE	KS	56
AB	LOS ALAMOS	NM	BD	BOULDER	∞	56
AU	AUSTIN	TX	DL	RICHARDSON	TX	1544
BD	BOULDER	∞	MD	MADISON	WI	224
BD	BOULDER	$\widetilde{\mathbf{\omega}}$	DC	WASHINGTON	DC	224
BD	BOUTLDER	$\widetilde{\mathbf{x}}$	SL	SALT LAKE CITY	UT	56
BD	BOULDER	$\tilde{\omega}$	DC	WASHINGTON	DC	224
BD	BOULDER	$\widetilde{\mathbf{x}}$	BO	WOODS HOLE	MA	224
BD	BOULDER	$\widetilde{\mathbf{x}}$	MI	MIAMI	FL	224
BD	BOULDER	$\widetilde{\mathbf{x}}$	TU	TUCSON	AZ	56
BD	BOULDER	88	DT	ANN ARBOR	MI	
BD	BOULDER	88	PO	CORVALIS	OR	224 1544
BD	BOULDER	$\frac{3}{8}$	PO	CORVALLIS CORVALLIS		
BD	DENVER	$\frac{3}{8}$	LA	LOS ANGELES	OR CT	224
BO	BOSTON	MA.	NY		CA	1544
BO	CAMBRIDGE	MA MA		NEW YORK	NY	1544
CH.	CHICAGO		PR	PRINCETON	NJ	1544
CH CH	CHICAGO	IL	SE	SEATTLE	WA	1544
CH CH	CHICAGO	IL	DT	LANSING	MI	1544
CH CH		IL	DT	LITCHFIELD	MI	1544
	CHICACO	IL	SF	SAN FRANCISCO	CA.	56
CH CH	CHICAGO	IL	MD	MADISON	WI	1544
CH CH	CHICAGO	IL	BD	DENVER	∞	1544
CH.	CHICAGO	IL	TL	TALLAHASSEE	FL	56
CH CH	CHICACO	IL	IL	URBANA	IL	1544
CH CH	CHICAGO	IL	LI	LINCOLN	NE	1544
CH CH	CHICACO	IL	BO	CAMBRIDGE	MA	1544
DC DG	WASHINGTON	DC	NY	NEW YORK	NY	1544
DC	WASHINGTON	DC	AB	ALBUQUERQUE	NM	56
DC	WASHINGTON	DC	LL	LIVERMORE	CA	56
DC	WASHINGTON	DC	LL	LIVERMORE	CA.	56
DC	WASHINGTON	DC	LL	LIVERMORE	CA	56
DC	WASHINGTON	DC	HN	HUNTSVILLE	AL	56
DC	WASHINGTON	DC	HU	HOUSTON	TX	56
DC	WASHINGTON	∞	WI	WALLOPS ISLAND	VA	56
DC	WASHINGTON	∞	WI	WALLOPS ISLAND	VA	1544
DC	WASHINGTON	DC	CL	CLEVELAND	ОН	112
DC	WASHINGTON	DC	KN	CAPE KENNEDY	FL	168
DC	WASHINGTON	DC	LA	LOS ANGELES	CA.	56
DC	WASHINGTON	DC	WS	WHITE SANDS	NM	224
DC DC	WASHINGTON	DC	ws	WHITE SANDS	NM	56
	WASHINGTON	DC	LA	BARSTOW	CA	224

EXHIBIT ES-9. Current IRN Links & Capacity

DC DC DC	Washington Washington Washington	∞ ∞ ∞	LA BO PR	BARSTOW CAMBRIDGE PRINCETON	CA MA NJ	56 56 1544
DC	WASHINGTON	DC	SF	SAN FRANCISCO	CA	1544
DC	WASHINGTON	DC	SF	SAN FRANCISCO	CA	112
DC	WASHINGTON	DC	SF	SAN FRANCISCO	CA	224
DC	WASHINGTON	DC	HU	HOUSTON	TX	1544
DC	WASHINGTON	DC	LA	PASADENA	CA	448
DC	WASHINGTON	DC	LA	PASADENA	CA	280
DC	WASHINGTON	DC	LA	LOMPOC	CA	224
DC	WASHINGTON	DC	HN	HUNTSVILLE	AL	1544
DC	WASHINGTON	DC	KN	CAPE KENNEDY	FL	672
DC	WASHINGTON	DC	HN	HUNTSVILLE	AL	512
DC	WASHINGTON	DC	HU	HOUSTON	TΧ	56
DC	WASHINGTON	DC	HU	HOUSTON	TX	2048
DC	WASHINGTON	DC	PH	WILMINGTON	DE	56
DC	WASHINGTON	DC	NF	NORFOLK	VA	56
DC PC	WASHINGTON	DC	HU	HOUSTON	ΤX	56
DC DC	WASHINGTON	DC	KN	CAPE KENNEDY	FL	280
DC	WASHINGTON	DC	NY	NEW YORK	NY	56
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	56
DL	RICHARDSON	ΤX	TL	TALLAHASSEE	FL	1544
DT	ANN ARBOR	MI	CB	COLUMBUS	OH.	1544
DT	ANN ARBOR	MI	PR	PRINCETON	NJ	1544
HN	HUNTSVILLE	AL	KN	CAPE KENNEDY	FL	2048
HN HN	HUNTSVILLE	AL	HU	HOUSTON	TX	168
	HUNTSVILLE	AL	DC	WASHINGTON	DC	672
HN HN	HUNTSVILLE	AL	KN	ORLANDO	FL	56
HU	HUNTSVILLE BRYAN	AL	MI	MIAMI	FL	56
HU	HOUSTON	TX	AU	AUSTIN	ΤX	1544
HU	HOUSTON	IX X	DL HN	DALLAS	TX	56
HU	HOUSTON	TX	WS	HUNTSVILLE WHITE SANDS	AL	56
HU	HOUSTON	ΤX	AU	AUSTIN	NM	56
HU	HOUSTON	ΪX	AU	AUSTIN	ΙX	1544
HU	HOUSTON	ΪX	BD	BOULDER	X Ω	56 1544
HU	HOUSTON	ΪX	AU	AUSTIN	TΧ	56
HU	HOUSTON	ΤX	KN	CAPE KENNEDY	FL	1544
IL	URBANA	IL	ĊН	CHICAGO	IL	1544
IL	URBANA	IL	IN	BLOOMINGTON	IN	1544
IL	URBANA	IL	MD	MILWAUKEE	WI	56
IN	INDIANAPOLIS	IN	CB	COLUMBUS	OH	1544
IO	IOWA CITY	IA	IL	URBANA	IL	1544
IT	ITHACA	NY	NY	NEW YORK	NY	1544
IT	ITHÀCA	NY	NY	NEW YORK	NY	1544
IT	ITHACA	NY	NY	NEW YORK	NY	1544
IT	ITHACA	NY	DC	WASHINGTON	DC	1544
IT	ITHACA	NY	PT	PITTSBURGH	PA	1544
KS	KANSAS CITY	KS	LL	LIVERMORE	CA	56
KS	KANSAS CITY	KS	LL	LIVERMORE	CA	1544
KS	KANSAS CITY	KS	AB	ALBUQUERQUE	NM	1544
LA	LOS ANGELES	CA	AB	LOS ALAMOS	NM	1544
LA	LOS ANGELES	CA.	HN	HUNTSVILLE	AL	56

EXHIBIT ES-9. Current IRN Links & Capacity

(Continued)

	100 111					
LA	LOS ANGELES	CA	SD	SAN DIEGO	CA	56
LA	LOS ANGELES	CA.	SD	SAN DIEGO	CA	56
LA	LOS ANGELES	CA	SF	SAN FRANCISCO	CA	1544
LA	LOS ANGELES	CA	HU	HOUSTON	TX	56
LA	LOS ANGELES	CA	BD	BOULDER	$\overline{\omega}$	56
LA	LOS ANGELES	CA	SD	SAN DIEGO	œ.	1544
LA	LOS ANGELESO	ĞĂ.	SF	SAN FRANCISCO		
LA	PASADENA	ĞÂ.	TU	TUCSON	CA.	1544
LA	PASADENA	ΘĀ.	DC		AZ	56
LA				BALTIMORE	MD	56
	PASADENA	CA.	HU	HOUSTON ISLAND		168
LA	PASADENA	CA.	DC	WASHINGTON	DC	672
LI	LINCOLN	NE	IL	URBANA	IL	56
LI	LINCOLN	NE	KS	LAWRENCE	KS	56
LI	LINCOLN	NE	IO	IOWA CITY	IA	56
LI	LINCOLN	NE	BD	BOULDER	∞	1544
LL	LIVERMORE	CA	SF	OAKLAND .	ŒĀ	56
LL	LIVERMORE	CA	PR	PRINCETON	ŊJ	1544
LL	LIVERMORE	CA	LA	LOS ANGELES	ĊĂ	56
LL	LIVERMORE	CA	AB	ALBUQUERQUE	NM	1544
MP	MINNEAPOLIS	MN	IO	IOWA CITY		
MP	MINNEAPOLIS	MN	MD	MADISON	IA	1544
NF	NORFOLK	VA	TL		WI	1544
NY	LONG ISLAND			TALLAHASSEE	FL	1544
NY		NY	BO	CAMBRIDGE	MA	1544
	NEW YORK	NY	IT	ROME	NY	1544
OR	OAK RIDGE	IN	CH	CHICAGO	IL	1544
OR	OAK RIDGE	TN	TL	TALLAHASSEE	FL	1544
PR	PRINCETON	NJ	TU	TUCSON	ΑZ	1544
PR	PRINCETON	LN	NF	NORFOLK VA	DC	1544
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544
PR	PRINCETON	NJ	ĊН	CHICAGO	IL	1544
PR	PRINCETON	NJ	NY	LONG ISLAND	NY	1544
PR	PRINCETON	NJ	BD	BOLDER	$\overset{\dots}{\infty}$	1544
PR	PRINCETON	NJ	SC	STATE COLLEGE	PA	
PR	PRINCETON	NJ	PH	PHILADELPHIA		1544
PR	PRINCETON	NJ	BO	CAMBRIDGE	PA	1544
PR	PRINCETON	NJ			MA	1544
PR	PRINCETON		BO	CAMBRIDGE	MA	1544
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544
PR		ŊJ	NY	NEW YORK	NY	1544
PR	PRINCETON	NJ	BO	NEW HAVEN	CI	1544
	PRINCETON	ŊJ	B O	AMHERST	MA	1544
PT	PITTSBURGH	PA	SC	STATE COLLEGE	PA	1544
PT	PITTSBURGH	PA	PR	PRINCETON	ŊJ	1544
PT	PITTSBURGH	PA	IL	URBANA	IL	1544
PT	PITTSBURGH	PA	CL	CLEVELAND	OH	1544
PT	PITTSBURGH	PA	PH	PHILADELPHIA	PA	1544
PT	PITTSBURGH	PA	DC	WASHINGTON	DC	1544
SD	SAN DIEGO	CA.	LA	LOS ANGELES	CA.	1544
SD	SAN DIEGO	CA.	LA	RIVERSIDE	CA.	56
SD	SAN DIEGO	CA	LA	LOS ANGELES	ČĀ.	1544
SD	SAN DIEGO	CA	LA	LOS ANGELES	CA.	1544
SD	SAN DIEGO	CA	HU	HOUSTON	ΪX	1544
SD	SAN DIEGO	ĊĂ.	SF	MENLO PARK	ĆĄ.	1544
SD	SAN DIEGO	ĞĂ.	LA	SANTA BARBARA		
		<u>-</u> .	<u>.</u> .	A SUMITY DAKDAKA	CA	56
				-		

EXHIBIT ES-9. Current IRN Links & Capacity

(Continued)

					,	446004
WI	WALLOPS ISLAND	VA	HU	HOUSTON	TX	224
WI	WALLOPS ISLAND	VA	MD	MADISON	WI	224
WI	WALLOPS ISLAND	VA	HU	HOUSTON	TX	1544
SL	SALT LAKE CITY	UI	CH	CHICAGO	IL	1544
SL	SALT LAKE CITY	UT	BD	BOULDER	∞	1544
SL	SALT LAKE CITY	UT	SF	MENLO PARK	CA	1544
SF	SAN FRANCISCO	CA	CH	CHICAGO	IL	1544
SF	SAN FRANCISCO	CA	DC	WASHINGTON	DC	56
SF	SAN FRANCISCO	CA	LA	LOS ANGELES	CA.	56
SF	SAN FRANCISCO	CA	DC	WASHINGTON	DC	336
SF	SAN FRANCISCO	CA	BD	BOULDER	∞	56
SF	SAN FRANCISCO	CA	LL	LIVERMORE	CA.	1544
SF	SAN FRANCISCO	CA	LA	PASADENA	CA	448
SE	SEATTLE	WA	PO	EUGENE	OR	56
SE	SEATTLE	WA	PO	CORVALLIS	OR	56
SE	SEATTLE	WA	PO	PORTLAND	OR	56
SE	SEATTLE	WA	SF	MENILO PARK	ĊĀ	1544
SE	SEATTLE	WA.	SD	SAN DIEGO	ĊĀ	1544
SD	SAN DIEGO	ĊA.	SL	SALT LAKE CITY	UT	56
SD	SAN DIEGO	CA	SL	SALT LAKE CITY	ŬĪ	56
SD	SAN DIEGO	ČA	LA	IRVINE	ĊĀ.	56
SD	SAN DIEGO	ĞĂ.	SF	OAKLAND	CA	56
SD	SAN DIEGO	CA	SE	SEATTLE	WA	56

sum 146824

EXHIBIT ES-9. Current IRN Links & Capacity

(Continued)

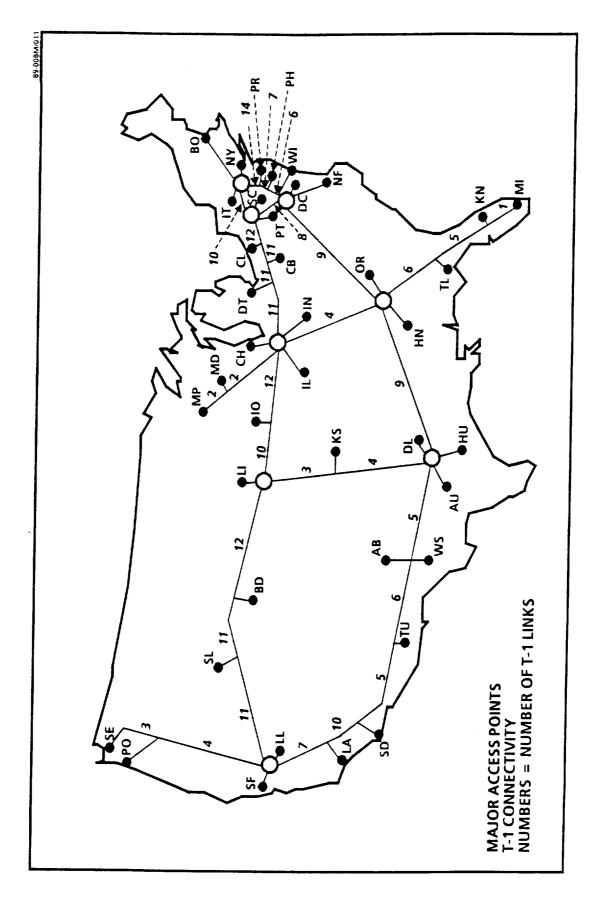


EXHIBIT ES-10. Current IRN Topology

3.5.1 1991 IRN Links And Topology

The 1991 IRN links are listed in Exhibit ES-11. The names of the 1991 links are identical to the Current IRN links that were presented in Exhibit ES-9. Again, the ID (i.e., major access point identification), name and state for City A and for City B and the capacity for each City A/City B link are listed. The major change from the Current IRN to the 1991 IRN was the increase in capacity from T1 to T3 on some links. It was assumed that the NSFNET Backbone capacity would increase from T1 to T3 by 1991, and this expected increase was reflected in the 1991 IRN backbone.

The 1991 IRN Topology is depicted in Exhibit ES-12. The 1991 connectivity has not changed from the Current (i.e., 1989) connectivity, but the capacity of the IRN backbone has. Much of the 1991 IRN backbone is projected to have T3 capacity in 1991.

3.5.2 1996 IRN Links And Topology

For the 1996 IRN, ten new major access points were added, making a total of fifty major access points. These fifty major access points are listed in Exhibit ES-13. The ten new major access points are: Atlanta, Billings, Cheyenne, Columbus, Columbia, Fargo, Helena, Jacksonville, New Orleans, Raleigh and St Louis.

The 1996 IRN links are listed in Exhibit ES-14. As with the Current and 1991 IRN link lists, the ID (i.e., major access point identification), name and state for City A and for City B and the capacity for each City A/City B link are listed. However, even though the number of major access points has increased by ten, the number of links listed has decreased from 177 links in 1991 to 53 links in 1996. This is because only direct links are listed for 1996. For example, in 1996 there are only two links from Seattle (Seattle to Helena and Seattle to San Francisco), while in 1991 there were five. This change in procedure for listing links was made because the 1996 IRN was assumed to be a truly single integrated network, while the 1991 and Current (1989) IRNs were assumed to be composites of many networks with several individual links.

1991 IRN LINKS

				**========	====	=========	
II	CITY - A	ST	ID	CITY	ST	CAPACI	ITY .
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA	56	
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA	1544	
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56	
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56	
AB	ALBUQUERQUE	NM	KS	KANSAS CITY	KS	56	
AB	ALBUQUERQUE	NM	LL	LIVERMORE	CA	56	
AB	LOS ALAMOS	NM	AU	AUSTIN	TΧ	56	
AB	LOS ALAMOS	NM	KS	LAWRENCE	KS	56	
AB	LOS ALAMOS	NM	BD	BOULDER	∞	56	
ĽΑ	AUSTIN	TX	DL	RICHARDSON	TX	1544	
BD	BOULDER	∞	MD	MADISON	WI	224	
BD	BOULDER	∞	DC	WASHINGTON	DC	224	
BD	BOULDER	∞	SL	SALT LAKE CITY	UT	56	
BD	BOULDER	∞	DC	WASHINGTON	DC	224	
BD	BOULDER	∞	B O	WOODS HOLE	MA	224	
BD	BOULDER	∞	MI	MIAMI	FL	224	
BD	BOULDER	∞	TU	TUCSON	AZ	56	
BD	BOULDER	∞	DT	ANN ARBOR	MI	224	
BD	BOULDER	∞	PO	CORVALIS	OR	1544	
BD	BOULDER	∞	P O	CORVALLIS	OR.	224	
BD	DENVER	∞	LA	LOS ANGELES	CA	1544	
BO	BOSTON	MA	NY	NEW YORK	NY	1544	
BO	CAMBRIDGE	MA	PR	PRINCETON	NJ	1544	
CH CH	CHICACO	IL	SE	SEATTLE	WA.	4 4M	
CH CH	CHICAGO	IL	DT	LANSING	MI	1544	
CH CH	CHICAGO	IL	DT	LITCHFIELD	MI	1544	
	CHICAGO	IL	SF	SAN FRANCISCO	CA	56	
स स	CHICAGO	IL	MD	MADISON	WI	1544	
	CHICAGO CHICAGO	IL	BD	DENVER	∞	4 4M	
CH CH		IL	TL	TALLAHASSEE	FL	56	
CH.	CHICAGO CHICAGO	IL	IL	URBANA	IL	1544	
CH.	CHICAGO	IL	Ш	LINCOLN	NE	4 4M	
DC	WASHINGTON	IL DC	BO	CAMBRIDGE	MA	1544	
DC	WASHINGTON	DC	NY AB	NEW YORK	NY	1544	
DC	WASHINGTON	DC	MD LL	ALBUQUERQUE	NM CD	56	
$\widetilde{\mathbb{DC}}$	WASHINGTON	DC	LL	LIVERMORE LIVERMORE	CA CA	56	
DC	WASHINGTON	DC			CA.	56	
DC	WASHINGTON	DC	LL HN	LIVERMORE HUNTSVILLE	CA	56 5.6	
DC	WASHINGTON	$\overset{\sim}{\mathbb{DC}}$	HU	HOUSTON	AL	56 5.6	
DC	WASHINGTON	$\overset{\infty}{\mathbb{C}}$	WI	WALLOPS ISLAND	TX	56	
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA VA	56	
DC	WASHINGTON	DC	ĈĹ.	CLEVELAND	VA. OH	1544	
DC	WASHINGTON	$\overset{\sim}{\infty}$	KIN	CAPE KENNEDY	FL	112	
DC	WASHINGTON	DC	LA	LOS ANGELES		168	
DC	WASHINGTON	DC	WS	WHITE SANDS	CA NM	56	*
DC	WASHINGTON	$\widetilde{\mathbb{DC}}$	WS	WHITE SANDS	NM NM	224 56	
DC	WASHINGTON	DC	LA	BARSTOW	CA.	224	
			·	5/DION	∽	44	

EXHIBIT ES-11. 1991 IRN Links & Capacity

DC	WASHINGTON	DC	LA	BARSTOW	~ ™	E C
DC		DC		CAMBRIDGE	CA MA	56 56
DC		DC		PRINCETON	MA NJ	56
DC		DC		SAN FRANCISCO	O CA	4 4M
DC		DC		SAN FRANCISCO		1544
DC		DC	SF	SAN FRANCISCO		112
DC	WASHINGTON	DC	HU	HOUSTON		224
DC	WASHINGTON	DC	LA	PASADENA	TX	4 4M
DC	WASHINGTON	DC	LA	PASADENA	CA CT	448
DC	WASHINGTON	DC	LA	LOMPOC	CA CT	280
DC	WASHINGTON	DC	HN	HUNTSVILLE	CA ar	224
DC	WASHINGTON	DC	KIN	CAPE KENNEDY	AL FL	1544
DC	WASHINGTON	DC	HN	HUNTSVILLE		672
DC	WASHINGTON	DC	HU	HOUSTON	AL	512
$\mathbb{D}C$	WASHINGTON	DC	HU	HOUSTON	IΧ	56
DC	WASHINGTON	DC	PH	WILMINGTON	TX	2048
DC	WASHINGTON	DC	NF	NORFOLK	DE	56
DC	WASHINGTON	DC	HU	HOUSTON	VA	56
DC	WASHINGTON	DC	KN		TX	56
DC	WASHINGTON	DC	NY	CAPE KENNEDY	FL	280
DC	WASHINGTON	DC	WI	NEW YORK	NY	56
DL	RICHARDSON	TX	TL	WALLOPS ISLAND		56
DT	ANN ARBOR	MI	CB	TALLAHASSEE	FL	1544
DT	ANN ARBOR	MI	PR	COLUMBUS	OH	1544
HN	HUNTSVILLE	AL		PRINCETON	NJ	44M
HN	HUNTSVILLE	AL AL	KN	CAPE KENNEDY	FL	2048
HN	HUNTSVILLE		HU	HOUSTON	TX	168
HIN	HUNTSVILLE	AL	DC	WASHINGTON	DC	672
HN	HUNTSVILLE	AL	KN	ORLANDO	FL	56
HU	BRYAN	AL	MI	MIAMI	FL	56
HU	HOUSTON	ΤX	AU	AUSTIN	TX	1544
HU	HOUSTON	ΊX	DL	DALLAS	TX	56
HU	HOUSTON	ΊX	HN	HUNTSVILLE	AL	56
HU	HOUSTON	TX	WS	WHITE SANDS	NM	56
HU	HOUSTON	TX	AU	AUSTIN	TX	1544
HU	HOUSTON	TX	AU	AUSTIN	TX	56
HU	HOUSTON	TX	BD	BOULDER	∞	44M
HU	HOUSTON	ΤX	AU	AUSTIN	TX	56
IL	URBANA	ΤX	KN	CAPE KENNEDY	FL	1544
IL	URBANA URBANA	ΪĻ	CH .	CHICAGO	IL	1544
IL		IL	IN	BLOOMINGTON	IN	1544
IN	URBANA	IL	MD	MILWALIKEE	WI	56
IO	INDIANAPOLIS IOWA CITY	IN	CB	COLUMBUS	OH	1544
IT	ITHACA	IA	IL	URBANA	IL	1544
IT		NY	NY	NEW YORK	NY	1544
IT	ITHACA	NY	NY	NEW YORK	NY	1544
IT	ITHACA	NY	NY	NEW YORK	NY	1544
IT	ITHACA	NY	DC	WASHINGTON	DC	44M
KS	ITHACA	NY	PT	PITTSBURGH	PA	4 4M
KS KS	KANSAS CITY	KS	LL	LIVERMORE	CA	56
	KANSAS CITY	KS	LL	LIVERMORE	CA.	1544
KS	KANSAS CITY	KS	AB	ALBUQUERQUE	NM	1544
LA	LOS ANGELES	CA.	AB	LOS ALAMOS	NM	1544
LA	LOS ANGELES	CA	HN	HUNTSVILLE	AL	56

EXHIBIT ES-11. 1991 IRN Links & Capacity

LA	LOS ANGELES	CA	SD	SAN DIEGO	CA	56
LA	LOS ANGELES	CA	SD	SAN DIEGO	CA	56
LA	LOS ANGELES	CA.	SF	SAN FRANCISCO	CA	1544
LA	LOS ANGELES	ĆĀ	HU	HOUSTON	TX	56
LA	LOS ANGELES	ĊĀ.	BD	BOULDER	$\overline{\infty}$	56
LA LA	LOS ANGELES		SD	SAN DIEGO	œ Œ	1544
		CA.				
LA	LOS ANGELESO	CA.	SF	san francisco	CA	1544
LA	PASADENA	CA.	TU	TUCSON	AZ	56
LA	PASADENA	CA.	DC	BALTIMORE	MD	56
LA	Pasadena	CA	HU	HOUSTON ISLAND	TX	168
LA	PASADENA	CA	DC	WASHINGTON	DC	672
LI	LINCOLN	NE	IL	URBANA	IL	56
LI	LINCOLN	NE	KS	LAWRENCE	KS	56
LI	LINOLN	NE	IO	IOWA CITY	IA	56
LI	LINCOLN	NE	BD	BOULDER	$\tilde{\alpha}$	4 4M
LL				OAKLAND	Œ	56
	LIVERMORE	ÇA .	SF			
LL	LIVERMORE	CA. `	PR	PRINCETON	ŊJ	1544
LL	LIVERMORE	CA.	LA	LOS ANGELES	CA	56
LL	LIVERMORE	CA.	AB	ALBUQUERQUE	NM	1544
MP	MINNEAPOLIS	MN	IO	IOWA CITY	IA	1544
MΡ	MINNEAPOLIS	MN	MD	MADISON	WI	1544
NF	NORFOLK	VA	TL	TALLAHASSEE	FL	1544
NY	LONG ISLAND	NY	BO	CAMBRIDGE	MA	1544
NY	NEW YORK	NY	IT	ROME	NY	1544
OR	OAK RIDGE	TN	äн	CHICAGO	IL	1544
OR	OAK RIDGE	TN	TL	TALLAHASSEE	FL	1544
					AZ	1544
PR	PRINCETON	NJ	TU	TUCSON		
PR	PRINCETON	NJ	NF	NORFOLK VA	∞	1544
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544
PR	PRINCETON	NJ	α H	CHICAGO	IL	1544
PR	PRINCETON	ŊJ	NY	LONG ISLAND	NY	1544
PR	PRINCETON	NJ	BD	BOLDER	∞	1544
PR	PRINCETON	NJ	SC	STATE COLLEGE	PA	1544
PR	PRINCETON	NJ	PH	PHILADELPHIA	PA	1544
PR	PRINCETON	NJ	ВО	CAMBRIDGE	MA	1544
PR	PRINCETON	NJ	80	CAMERIDGE	MA	1544
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544
PR	PRINCETON			NEW HAVEN		
		ŊJ	BO		CI	1544
PR	PRINCETON	ИJ	ВО	AMHERST	MA	1544
PT	PITTSBURGH	PA	SC	STATE COLLEGE	PA	1544
PT	PITTSBURGH	PA	PR	PRINCETON	NJ	4 4 M
PT	PITTSBURGH	PA	IL	URBANA	IL	4 4M
PT	PITTSBURGH	PA	CL	CLEVELAND	OH:	1544
PT	PITTSBURGH	PA	PH	PHILADELPHIA	PA	1544
PT	PITTSBURGH	PA	DC	Washington	DC	1544
SD	SAN DIEGO	CA	LA	LOS ANGELES	CA.	1544
SD	SAN DIEGO	CA.	LA	RIVERSIDE	CA	56
SD	SAN DIEGO	ĆΆ	LA	LOS ANGELES	ĊĀ	1544
SD	SAN DIEGO	ČA.	LA	LOS ANGELES	ČA.	1544
SD	SAN DIEGO	σ _λ	HU	HOUSTON	ΤX	44M
			SF	MENLO PARK		
SD	SAN DIEGO	CA CA			CA.	4 4M
ŞD	SAN DIEGO	CA	LA	s an ta barbara	CA	56

EXHIBIT ES-11. 1991 IRN Links & Capacity

SD	SAN DIEGO	CA	SE	SEATTLE	WA	56
SD	SAN DIEGO	CA	SF	CAKLAND	CA	56
SD	SAN DIEGO	CA	LA	IRVINE	CA	56
SD	SAN DIEGO	CA.	SL	SALT LAKE CITY	UT	56
SD	SAN DIEGO	CA	SL	SALT LAKE CITY	UT	56
SE	SEATTLE	WΑ	SD	SAN DIEGO	CA.	4 4M
SE	SEATTLE	WA	SF	MENLO PARK	CA	4 4M
SE	SEATTLE	WA	PO	PORTLAND	OR.	56
SE	SEATTLE	WA	PO	CORVALLIS	OR.	56
SE	SEATTLE	WA	PO	EUGENE	OR	56
SF	san francisco	CA	LA	PASADENA	CA.	448
SF	SAN FRANCISCO	CA	LL	LIVERMORE	CA.	1544
SF	san francisco	CA	BD	BOULDER	∞	56
SF	SAN FRANCISCO	CA:	DC	WASHINGTON	DC	336
SF	SAN FRANCISCO	CA	LA	LOS ANGELES	CA.	56
SF	SAN FRANCISCO	CA	DC	WASHINGTON	DC	56
SF	SAN FRANCISCO	CA	CH ·	CHICAGO	IL	1544
SL	SALT LAKE CITY	UI	SF	MENLO PARK	CA.	4 4M
SL	SALT LAKE CITY	UΤ	BD	BOULDER	∞	44M
SL	SALT LAKE CITY	UT	CH	CHI CACO	IL	4 4M
WI	WALLOPS ISLAND	VA	HU	HOUSTON	TΧ	1544
WI	WALLOPS ISLAND	VA	MD	MADISON	WI	224
WI	WALLOPS ISLAND	VA	HU	HOUSTON	TX	224

sum

EXHIBIT ES-11. 1991 IRN Links & Capacity

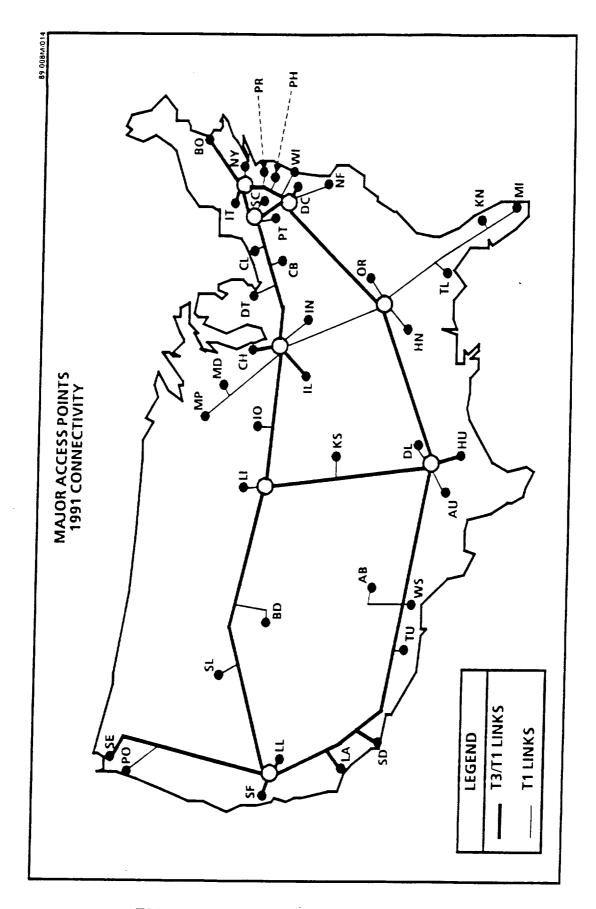


EXHIBIT ES-12. 1991 IRN Topology

KEY	CITY	STATE	V	Н
AB	ALBUQUERQUE	NM	8549	5887
AT	ATLANTA	GA.	7243	
AU	AUSTIN	TX		
BI	BILLINGS	TM	9005	
B O	BOSTON		6390	6790
BD	BOULDER	MA ~~	4422	1249
CY	CHEYENNE	∞	7456	5961
CH CH	CHICACO	WY	7204	5958
CL.		IL	5986	3426
æ	CLEVELAND	ОH	5574	2543
	WILLIA	SC	6902	1587
CB	WILLIAMBUS	OH.	5972	2555
DL	DALLAS	TX	8436	4034
DT	DETROIT	MI	5536	2828
FR	FARGO	ND	5614	5181
Æ	HELENA	MI	6339	
U	HOUSTON	īx		7350
<u>I</u> N	HUNTSVILLE	AL	8938	3536
N	INDIANAPOLIS		7267	2535
:0	IOWA CITY	IN	6272	2992
T	ITHACA	IA	6315	3971
ĸ	JACKSONVILLE	NY	4798	199C
s		FL	7642	1276
N	KANSAS CITY	MO	7249	4210
I	KENNEDY SPC CIR	FL	7919	0880
L	LINCOLN	NE	6823	4674
	LIVERMORE	CA.	8504	8606
4	LOS ANGELES	CA.	9213	7878
2	MADISON	WI	5890	3798
[MIAMI	FL	8351	0527
	MINNEAPOLIS	MEN	5781	4525
)	NEW ORLEANS	LA	8484	
,	NEW YORK	NY	4997	2631
•	NORFOLK	VA		1406
	OAK RIDGE	TN	5936	1198
	PHILADELPHIA		6811	2303
	PITTSBURGH	PA	5251	1458
	PORTLAND	PA ~~	5621	2185
	PRINCETON	OR	6799	8914
	RALEIGH	ŊJ	5120	1436
	SALT LAKE	NC	6344	1434
		υī	7576	7065
	SAN DIECO	CA.	9468	7629
	SAN FRANCISCO	CA.	8492	8719
	SEATTLE	WA	6336	8896
	ST LOUIS	MO	6807	3483
	STATE COLLEGE	PA	5360	1933
	TALLAHASEE	FL	7876	1715
	TUCSON	AZ	9342	648C
	URBANA	IL	6371	3336
	WALLOPS ISLAND	VA	5657	1249
	WASHINGTON	DC	5622	1583
	WHITE SANDS			

EXHIBIT ES-13. 1996 IRN Major Access Points

ID	CITY - A	ST	ID	CITY - B	ST	CAPACITY
AB	ALBUQUERQUE	NM	HU	HOUSTON	TX	565M
AT	ATLANTA	GΑ	œ	COLUMBIA	SC	90M
AT	ATLANTA	GA	TL	TALLAHASEE	FL	90M
AU	AUSTIN	TX	DL	DALLAS	TΧ	90M
BD	BOULDER	∞	AB	ALBUQUERQUE	NM	90M
BD	BOULDER	∞	SF	SAN FRANCISCO	CA	1G
BI	BILLINGS	MT	CY	CHEYENNE	WY	90M
BI	BILLINGS	MI	FR	FARGO	ND	90M
ВО	BOSTON	MA	NY	NEW YORK	NY	1G
CB	WILLIMBUS	ОH	DT	DETROIT	MI	90 M
CH CH	CHICAGO	IL	IL	URBANA	IL	1G
CH	CHICAGO	IL	OR.	OAK RIDGE	IN	565M
CH CH	CHICAGO	IL	LI	LINCOLN	NE	
CH CH	CHICAGO	IL	DT	DETROIT		1G
CH CH	CHICAGO				MI	90M
CL CL	CLEVELAND	IL	ST	ST LOUIS	MO	90M
		OH	CB	CLUMBUS	ОH	90M
∞	COLUMBIA COLUMBIA	SC	RL	RALEIGH	NC	90M
CY	CHEYENNE	WY	BD	BOULDER	∞	90M
DC	WASHINGTON	DC	PT	PITTSBURGH	PA	16
DC	WASHINGTON	DC	NF	NORFOLK	VA	56 5M
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	90 M
FR	FARGO .	ND	MP	MINNEAPOLIS	MN	90M ·
HE	HELENA	MT	BI	BILLINGS	MT	9 0M
HN	HUNTSVILLE	AL	OR.	OAK RIDGE	TN	90M
HU	HOUSTON	TX	OR.	OAK RIDGE	IN	56 5M
HU	HOUSTON	TX	NO	NEW ORLEANS	LA	90M
IN	INDIANAPOLIS	IN	CH	CHICAGO	IL	9 0M
IT	ITHACA	NY	NY	NEW YORK	NY	1G
KN	KENNEDY SPC CT	R FL	MI	MIAMI	FL	90M
LA	LOS ANGELES	CA.	SD	SAN DIEGO	CA	1G
LI	LINCOLN	NE	HU	HOUSTON	TX	1G
LI	LINCOLN	NE	BD	BOULDER	∞	1G
LI	LINCOLN	NE	IO	IOWA CITY	IA	90M
MD	MADISON	WI	CH	CHICAGO	IL	565M
MP	MINNEAPOLIS	MN	MD	MADISON	WI	565M
NO	NEW ORLEANS	LA	TL	TALLAHASEE	FL	90M
NY	NEW YORK	NY	DC	WASHINGTON	DC	1G
NY	NEW YORK	NY	PT	PITTSBURGH	PA	1G
OR.	OAK RIDGE	TN	TL	TALLAHASEE	FL	565M
PO	PORTLAND	OR.	SE	SEATTLE	WA.	90M
PT	PITTSBURGH	PA	CL	CLEVELAND	OH	90M
PT	PITTSBURGH	PA	CH.	CHICAGO	IL	1G
RL	RALEIGH	NC	NF	NORFOLK	VA	90M
SC	STATE COLLEGE	PA	PT	PITTSBURGH	PA	90M
	SAN DIEGO	CA	AB	ALBUQUERQUE	NM	565M
	SEATTLE	WA	HE	HELENA	ΜT	90M
	SEATTLE	WA	SF	SAN FRANCISCO	CA	565M
	SAN FRANCISCO	CA	LL	LIVERMORE	CA.	1G
	SAN FRANCISCO	ĆA.	LA	LOS ANGELES	CA.	1G
	SALT LAKE	Ω.	BD	BOULDER	8	90M
	ST LOUIS	MO	KS	KANSAS CITY	MO	90M
	TALLAHASEE	FL	KN	KENNEDY SPC CIR		565M
	TUCSON	AZ	WS	WHITE SANDS	NM.	90M
				WILLE SANDS	INC.1	70[1

EXHIBIT ES-14. 1996 IRN Links & Capacity

The 1996 IRN topology is depicted in Exhibit ES-15. For the 1996 IRN, the 1991 IRN backbone still exists but its capacity has been increased. Also, the ten new major access points have been connected to this 1991 backbone. The following increases in capacity have been made:

- 1. Some of the 1991 T3 links have been increased to 1 Gbps links.
- 2. Some of the 1991 T3 links have been increased to 564/274 Mbps links.
- 3. All 1991 T1 links have been increased to 564/274 Mbps links.
- 4. The capacity of each of the links added to connect the ten new major access points was either 90 Mbps or 45 Mbps.

3.5.3 2000 IRN Links And Topology

The 2000 IRN links are listed in Exhibit ES-16. The major access points and connectivity for the 2000 IRN are identical to those for the 1996 IRN. The only changes that were made were in the link capacities.

The 2000 IRN topology is depicted in Exhibit ES-17. This topology map looks identical to the topology map for the 1996 IRN. However, the link capacities have been increased in the following manner:

- 1. All 1996 I Gbps links have been increased to 5 Gbps links.
- 2. All 1996 564/274 Mbps links have been increased to 1 Gbps links.
- 3. All 1996 90/45 Mbps links have been increased to 564/274 links.

3.5.4 2010 IRN Links And Topology

The 2010 IRN links are listed in Exhibit ES-18. Again, the major access points and connectivity for the 2010 IRN are identical to those for the 2000 IRN. As before, the only changes that were made were in the link capacities.

The 2010 IRN topology is depicted in Exhibt ES-19. This topology map again looks identical to the topology map for the 2000 IRN, and as before, the link capacities have been increased in the following manner:

- 1. All 2000 5 Gbps links have been increased to 25 Gbps links.
- 2. All 2000 1 Gbps links have been increased to 5 Gbps links.
- 3. All 2000 564/274 Mbps links have been increased to 1 Gbps links.

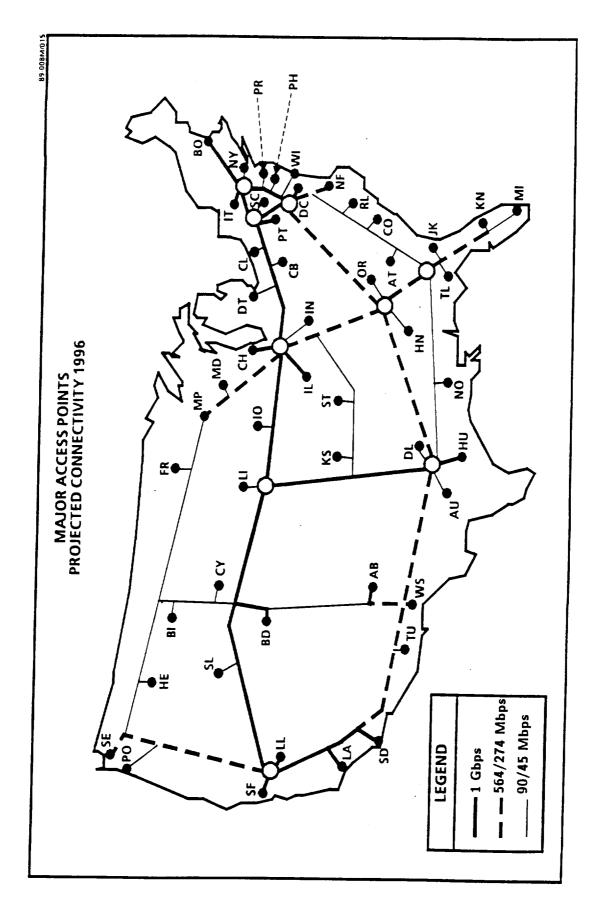


EXHIBIT ES-15. 1996 IRN Topology

YEAR 2000 IRN LINKS

=====		====		**************************************		
ID	CITY - A	ST	ID 	CITY - B	ST	CAPACITY
AB	ALBUQUERQUE	NM	HU	HOUSTON	TX	1G
AΤ	ATLANTA	GA	∞	COLUMBIA	SC	565M
AT	ATLANTA	GA	TL	TALLAHASEE	FL	56 5M
AU	AUSTIN	TX	DL	DALLAS	TX	565M
BD	BOULDER	$\tilde{\varpi}$	ĀB	ALBUQUERQUE	NM	565M
BD	BOULDER	$\overset{\sim}{\approx}$	SF	SAN FRANCISCO	CA	5G
	BILLINGS	MI		CHEYENNE	WY	565M
BI			C.Y.			
BI	BILLINGS	MT	FR	FARGO	ND	565M
BO	BOSTON	MA	NY	NEW YORK	NY	5G
CB	COLUMBUS	OH.	DT	DETROIT	MI	5 65M
CH	CHICAGO	IL	IL	URBANA	IL	5G
CH	CHICAGO	IL	OR	OAK RIDGE	TN	1G
CH	CHICAGO	IL	LI	LINCOLN	NE	5G
CH	CHICAGO	IL	DT	DETROIT	MI	5 65M
α H	CHICAGO	IL	ST	ST LOUIS	MO	56 5M
CL	CLEVELAND	OH	CB	COLUMBUS	OH	56 5M
∞	COLUMBIA	SC	RL	RALEIGH	NC	565M
CY	CHEYENNE	WY	BD	BOULDER	∞	565M
DC	WASHINGTON	DC	PT	PITTSBURGH	PA	5G
DC	WASHINGTON	DC	NF	NORFOLK	VA	1G
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	565M
FR	FARGO	ND	MP	MINNEAPOLIS	MN	565M
HE	HELENA	MI	BI	BILLINGS	MT	565M
HN	HUNTSVILLE	AL	OR	OAK RIDGE	TN	565M
				OAK RIDGE		
HU	HOUSTON	TX	OR Via		TN	1G
HU	HOUSTON	TX	NO	NEW ORLEANS	LA	565M
IN	INDIANAPOLIS	IN	CH.	CHICAGO	IL	565M
IT	ITHACA	NY	NY	NEW YORK	NY	5G
KN	KENNEDY SPC CTR		MI	MIAMI	FL	565M
LA	LOS ANGELES	CA.	SD	SAN DIEGO	CA	5G
LI	LINCOLN	NE	HU	HOUSTON	TX	5G .
LI	LINCOLN	NE	BD	BOULDER	∞	5G
LI	LINCOLN	NE	IO	IOWA CITY	IA	565M
MD	MADISON	WI	CH	CHICAGO	IL	1G
MP	MINNEAPOLIS	MN	MD	MADISON	WI	1G
NO	NEW ORLEANS	LA	TL	TALLAHASEE	FL	565M
NY	NEW YORK	NY	DC	WASHINGTON	DC	5G
NY	NEW YORK	NY	PT	PITTSBURGH	PA	5G
OR	OAK RIDGÉ	TN	TL	TALLAHASEE	FL	1G
PO	PORTLAND	OR.	SE	SEATTLE	A.W	56 5M
PT	PITTSBURGH	PA	α L	CLEVELAND	\circ H	565M
PT	PITTSBURGH	PA	CH	CHICAGO	IL	5G
RL	RALEIGH	NC	NF	NORFOLK	VA	565M
SC	STATE COLLEGE	PA	PT	PITTSBURGH	PA	565M
SD	SAN DIEGO	CA	AB	ALBUQUERQUE	NM	1G
SE	SEATTLE	WA	HE	HELENA	MT	56 5 M
SE	SEATTLE	WA	SF	SAN FRANCISCO	CA	1G
SF	SAN FRANCISCO	CA	LL	LIVERMORE	CA	5G
SF	SAN FRANCISCO	CA	LA	LOS ANGELES	CA	5G
SL	SALT LAKE	UT	BD	BOULDER	∞	565M
ST	ST LOUIS	MO	KS	KANSAS CITY	MO	565M
TL	TALLAHASEE	FL	KN	KENNEDY SPC CTR		1G
TU	TUCSON	AZ	WS	WHITE SANDS	NM	565M

EXHIBIT ES-16. 2000 IRN Links & Capacity

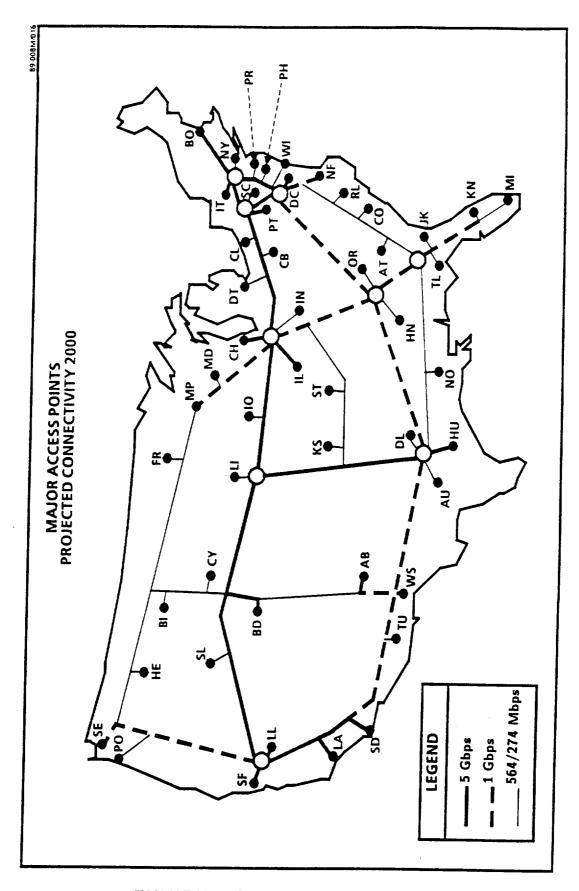


EXHIBIT ES-17. 2000 IRN Topology

YEAR 2010 IRN LINKS

ID	CITY -A	ST	ID	CITY - B	ST	CAPACITY
AB	ALBUQUERQUE	NIM	HU	HOUSTON	TX	5G
AT	ATLANTA	GA 🖜		COLUMBIA	SC	1G
ΑT	ATLANTA	GA	TL	TALLAHASEE	FL	1G
AU	AUSTIN	TX	DL	DALLAS	TX	1G
BD	BOULDER	∞	AB	ALBUQUERQUE	NM	1G
BD	BOULDER	∞	SF	SAN FRANCISCO	CA	25G
BI	BILLINGS	MI	CY	CHEYENNE	WY	1G
BI	BILLINGS	MT	FR	FARGO	ND	1G
BO	BOSTON	MA.	NY	NEW YORK	NY	25G
CB	COLUMBUS	\bigcirc H	DT	DETROIT	MI	1G
CH	CHICAGO	IL	IL	URBANA	IL	25G
CH.	CHICAGO	IL	OR	OAK RIDGE	TN	5G
CH	CHICAGO	IL	LI	LINCOLN	NE	25G
CH	CHICAGO	IL	DT	DETROIT	MI	1G
CH CH	CHICAGO	IL	ST	ST LOUIS	MO	iG
CL CL	CLEVELAND	OH	CB	COLUMBUS	OH	1G 1G
8	CLEVELAND COLUMBIA	SC	RL	RALEIGH	NC	
CY CY	CHEYENNE	WY				1G
DC	WASHINGTON		BD	BOULDER	∞	1G
		DC BG	PT	PITTSBURGH	PA	25G
DC DC	WASHINGTON	DC	NF	NORFOLK	VA	5G
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	1 <u>G</u>
FR	FARGO	ND	MP	MINNEAPOLIS	MN	1G
HE	HELENA	ΜT	BI	BILLINGS	MT	1G
HN	HUNTSVILLE	AL	OR.	OAK RIDGE	TN	IG
HU	HOUSTON	TX	OR.	OAK RIDGE	TN	5G
HU	HOUSTON	TX	NO	NEW ORLEANS	LA	IG
IN	INDIANAPOLIS	IN	CH	CHICAGO	IL	1G
IT	ITHACA	NY	NY	NEW YORK	NY	25G
KN	KENNEDY SPC CT	R FL	MI	MIAMI	FL	1G
LA	LOS ANGELES	CA	SD	SAN DIEGO	CA	25G
LI	LINCOLN	NE	HU	HOUSTON	TX	25G
LI	LINCOLN	NE	BD	BOULDER	∞	25G
LI	LINCOLN	NE	IO	IOWA CITY	IA	1G
MD	MADISON	WI	CH	CHICAGO	IL	5G
MP	MINNEAPOLIS	MN	MD	MADISON	WI	5G
NO	NEW ORLEANS	LA	TL	TALLAHASEE	FL	1G
NY	NEW YORK	NY	DC	WASHINGTON	DC	25G
NY	NEW YORK	NY	PT	PITTSBURGH	PA	25G
OR	OAK RIDGE	TN	TL	TALLAHASEE	FL	5G
PO	PORTLAND	OR	SE	SEATTLE	WA	1G
PT	PITTSBURGH	PA	CL CL	CLEVELAND	ОH	1G
PT	PITTSBURGH	PA	CH CH	CHICAGO	IL	25G
RL	RALEIGH	NC	NF	NORFOLK	VA	1G .
SC	STATE COLLEGE	PA	PT	PITTSBURGH	PA	1G
SD	SAN DIEGO	CA.	AB	ALBUQUERQUE	NM.	5G
SE	SEATTLE	WA.	HE	HELENA	MT	1G
SE	SEATTLE	WA.	SF	SAN FRANCISCO	CA	5G
SF	SAN FRANCISCO	CA.	LL	LIVERMORE	CA CA	25G
SF	SAN FRANCISCO	SA CA	LA	LOS ANGELES		
SL	SALT LAKE	57			CA.	25G
ST			BD	BOULDER	8	1G 1G 🏞
	ST LOUIS TALLAHASEE	MO FL	KS KN	KANSAS CITY KENNEDY SPC CTR	MO	
ידי		H I	K N	KENNEDY SPC (TD	H i	≒ (≥
TL TU	TUCSON	AZ	WS	WHITE SANDS	NM	5G 1G

EXHIBIT ES-18. 2010 IRN Links & Capacity

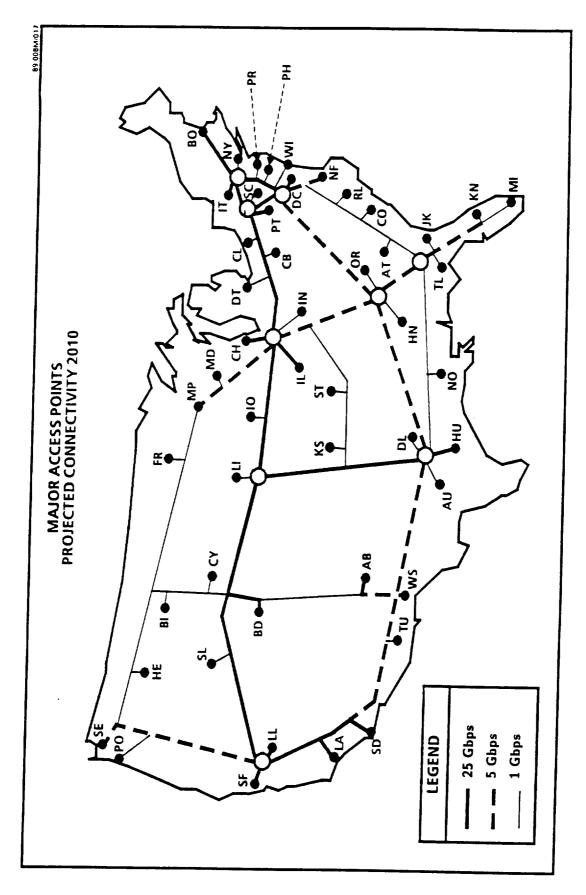


EXHIBIT ES-19. 2010 IRN Topology

3.6 ESTIMATES OF CURRENT AND FUTURE IRN COSTS

The major findings obtained from the activities conducted to estimate the current and future circuit costs of the IRN are presented in terms of the link costs and total costs for each of the selected benchmark years. In the following discussion of costs it was assumed that the IRN was not completely integrated in 1989 and 1991, but was so in 1996 and beyond.

3.6.1 Current (1989) IRN Circuit Costs

The circuit cost per month for each city-pair link and for the total Current (1989) IRN are shown in Exhibit ES-20. Again, the city-pairs are listed in the same order as they were listed in earlier exhibits listing the Current IRN links.

The concept of a "Megabit Per Second Mile" (MM) was developed to provide a measure of network efficiency across benchmark years. An MM refers to the movement of one Megabit Per Second of traffic one mile (i.e., an MM is a Mbps Mile). The number of MMs is indicated for each city-pair link.

The total Current IRN monthly cost of about 86,000 MMs, was estimated to be about 1.4 million dollars.

3.6.2 1991 IRN Circuit Costs

The cost per month for each city-pair link and for the total 1991 IRN are shown in Exhibit ES-21. The city-pairs are listed in the same order as they were listed in earlier exhibits listing the 1991 IRN links and as they were listed in Exhibit ES-20 which showed 1989 IRN costs. City-pair cost changes from 1989 to 1991 occurred only where the increases in the NSFNET backbone link speeds caused IRN city-pair link speed increases, and therefore link cost increases.

The total 1991 IRN monthly cost of about 661,000 MMs, was estimated to be about 2.4 million dollars. That is, compared with 1989, almost eight times as much traffic is expected to be moved in 1991 at less than twice the 1989 cost.

COST PER MONTH - CALCULATED BY USING AN ESTIMATED AVERAGE COST PER MILE FOR THE VARIOUS SERVICES

ID	CITY - A	ST	11	7177 - B	ST	CAPACITY	MILES	124	ODST
AB	ALBUQUERQUE	NM	11	LIVERMORE	СA	56	860	48.16	2,950.00
AΒ	ALBUQUERQUE	MSA	- ::	LIVERMORE	CA.	1544	860	1,327.84	14.300.00
ΑĐ	ALEUQUERQUE	224	H.3	HANSAS CITY	KS	56	671	37.58	2,477,50
AΕ	ALBUQUERQUE	224	KΞ	HANSAS CITY	K3	56	671	37.5e	2.477.50
AB	ALBUQUERQUE	325	KS	KANSAS CITY	KS	56	671	37.58	2.477.50 2.477.50
AB	ALBUQUERQUE	131	11	LIVERMORE	ĠĀ.	56	860	37.35 48.16	
AB	LOS ALAMOS	NM	AU	AUSTIN	ΤX	56	615	34.44	2.950.00
AB	LOS ALAMOS	NM	KS	LAWRENCE	KS	56	671		2.337.50
AB	LOS ALAMOS	NM	80	BOULDER	∞	56	346	37.58	2.477.50
AU	AUSTIN	77.	DL	RICHARDSON	$\frac{\infty}{m}$	1544	• • •	19.38	1.655.00
BD	BOULDER	\tilde{x}	MD	MADISON	WI		180	277.92	4,100.00
BD	BOULDER	$\widetilde{\alpha}$	DC	WASHINGTON	_	224	844	189.06	9.174.00
BD	BOULDER	$-\infty$	SL		DC	224	1.501	336.22	14.758.50
BD	BOULDER	$\frac{\infty}{\infty}$		SALT LAKE CITY		56	351	19.66	1,577.50
BD	BOULDER		DC	WASHINGTON	DC	224	1.501	336.22	14.758.50
BD		∞	ВО	WOODS HOLE	MA	224	1.772	396.93	17,062.00
	BOULDER	∞	MI	MIAMI	FL	224	1,742	390.21	15,807.00
BD	BOULDER	∞	TU	TUCSON	AZ	56	619	34.66	2.347.50
BD	BOULDER	∞	DT	ANIN ARBOR	MI	224	1,162	260.29	11.877.00
BD	BOULDER	∞	PO	CORVALIS	OR.	1544	957	1.477.61	15,755.00
BD	BOULDER	$_{\infty}$	PO	CORVALLIS	OR	224	957	214.37	10,134,50
BD	DENVER	∞	LA	LOS ANGELES	CA	1544	822	1.269.17	13.730.00
BO	BOSTON	MA	NY	NEW YORK	NY	1544	188	290.27	4,220.00
BO	CAMBRIDGE	MA	PR	PRINCETON	NJ	1544	229	353.58	4.835.00
CH .	CHICAGO	IL	SE	SEATTLE	WA	1544	1.733	2.675.75	
TH.	CHICACO	IL	DT	LANSING	MI	1544	237		27.395.00
⊐H.	CHICACO	IL	DT	LITCHFIELD	MI	1544	237	365.93	4,955.00
ŒH.	CHICACO	IL	SF	SAN FRANCISCO	ä	56		365.93	4,955.00
H	CHICAGO	ΪĹ	MD	MADISON	WI	1544	1.852	103.71	5.430.00
. H	CHICACO	IL	BD	DENVER	æ	1544	121	186.82	3,215.00
H	CHICAGO	ΪĹ		TALLAHASSEE			927	1.431.29	15.305.00
 ≱:	CHICACO	IL	TL TL	URBANA	FL	56	806	45.14	2.815.00
H.	CHICAGO		LI	LINCOLN	IL	1544	125	193.00	3.275.00
H	CHICAGO	IL IL	80		NE	1544	475	733.40	8,525.00
X.	WASHINGTON	DC	NY 80	CAMBRIDGE	MA	1544	848	1.309.31	14,120,30
ŶÇ.	WASHINGTON	DC		NEW YORK	NY	1544	205	316.52	4.475.00
Ť	WASHINGTON	20	AE	ALEUQUERQUE	NM.	56	1.646	92.18	4.915.00
ċ		50		LIVERMORE	CA .	56	2.401	134.46	5.802.50
č	WASHINGTON	DC		LIVERMORE	CA .	56	2.401	134.46	6,802.50
	WASHINGTON	20		LIVERMORE	CA.	56	2.401	134.4€	6.802.50
č –	WASHINGTON	DC	HN	HUNTSVILLE	AĽ.	56	501	33.66	2.302.56
<u>c</u>	WASHINGTON	DC	HU.	HOUSTON	TX	56	1.217	68.15	3,842.50
2	WASHINGTON	DC	WI	WALLOPS ISLAND	VA.	56	106	5.94	1.065.00
2	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	1544	106	163.66	2,990.00
2	Washington	DC	α	CLEVELAND	CH	112	304	34.05	2,568.00
	WASHINGTON	DC	K21	CAPE KENNEDY	FL	168	760	127.69	€,540.00
	WASHINGTON	00	LA	LOS ANGELES	CA.	56	2.292	128.35	
	WASHINGTON	DC	WS	WHITE SANDS	NM.	224	1.572	352.13	6.930.00
	WASHINGTON	DC	WS	WHITE SANDS	NM.	56	1.721	354.13 96.38	15.362.00
	WASHINGTON:	δē	Là	BARSTOW	ĊĀ.	224	2.292		5,102.50
	= ===				٠,	447	47-	513.41	21.482.00

DC	WASHINGTON	2.2	LA	EARSTOW	CA	56	2,292	128.35	5,530,00
DC	WASHINGTON	27		CAMBRIDGE	MA	56	394	22.0€	
DC	Washington	200	55	PRINCETON	NJ	1544	165		1.785.00
DC	WASHINGTON	D.		SAN FRANCISCO		1544		254.76	3.875.00
DC	WASHINGTON	50		SAN FRANCISCO			2,432	3,755.01	37.880.00
DC	Washington	50	SF			112	2.432	272.38	12.144.00
ĎĊ	WASHINGTON	500		SAN FRANCISCO		224	2,432	544.77	22,672.00
		U*.	HI.	HOUSTON	TK	1544	1.217	1.879.05	19,655.00
DC.	WASHINGTON	DC	LA	PASADENA	CA	448	2.292	1,026.82	35.780.00
500	WASHINGTON	DC	LA	Pasadenia	CA.	280	2.292	641.75	26,466.00
DC	Washington	DC.	ĹA	LOMPOC	CA	224	2,292	513.41	21.482.00
DC	Washington	20	HN	HUNTSVILLE	AL	1544	601	927.94	10.415.00
∞	WASHINGTON) DC	123	CAPE KENNEDY	FL	672	760	510.72	
DC	WASHINGTON	D C	HN	HUNTSVILLE	ΑĽ	512	601		12.800.00
DC	WASHINGTON	200	HU	HOUSTON	īx	. 56		307.71	10.415.00
DC	WASHINGTON	DC	HU	HOUSTON	TX		1,217	68.15	3.842.50
DC	WASHINGTON	50	bñ un			2048	1,217	2.492.42	29,482.50
DC DC	Washington			WILMINGTON	DE	56	124	6.94	1,110.00
50		DC	NF	NORFOLK	VA	56	157	8.79	1.192.50
	Washington	DC	HU	HOUSTON	TX	56	1,217	68.15	3.842.50
DC	WASHINGTON	DC	FIN	CAPE KENNEDY	FL	280	760	212.80	10.380.00
∞	WASHINGTON	∞	NY	NEW YORK	NY	56	205	11.48	1.312.50
DC	WASHINGTON	DC	WI	WALLOPS ISLAND) VA	56	106	5.94	1.065.00
DL	RICHARDSON	TΧ	TL	TALLAHASSEE	FL	1544	754	1.164.18	12.710.00
DT	ANN ARBOR	MI	Œ	COLUMBUS	ОH	1544	163		
DT	ANN ARBOR	MT	ÞÞ	PRINCETON	NJ	1544		251.67	3.845.00
HN	HUNTSVILLE	AL	KN	CAPE KENNEDY	FL	2048	459	708.70	9.285.00
HN	HUNTSVILLE	AL	HU	HOUSTON	TX		563	1.153.02	14,767.50
HN	HUNTSVILLE	AL	DC			168	616	103.49	5.604.00
HN	HUNTSVILLE	AL AL		WASHINGTON	DC	672	601	403.87	10,415.00
HN			KN	ORLANDO	FL	56	563	31.53	2.207.50
HU	HUNTSVILLE	AL	MI	MIAMI	FL	56	722	40.43	2,605.00
	BRYAN	ĪΧ	AU	AUSTIN	TX	1544	147	225.97	3,605.00
HU	HOUSTON	TX	DL	DALLAS	TX	56	224	12.54	1.360.00
HU	HOUSTON	TX	HN	HUNTSVILLE	AL	56	616	34.50	2,340.00
HU	HOUSTON	TX	WS	WHITE SANDS	NM	56	700	39.20	
HU	HOUSTON	TΧ	ΑU	AUSTIN	ΞX	1544	147		2.550.00
ĦU	HOUSTON	TX	AU	AUSTIN	ΪX	56	147	226.97	3.605.00
HU	HOUSTON	TX	BD	BOUTLDER	ά Έ	1544		8.23	1.167.50
HÜ	HOUSTON	77.	AU	AUSTIN	TX		899	1.388.06	14.885.00
HU	HOUSTON	ΪX	KIN	CAPE KENNEDY		56	147	8.23	1.167.50
IL	URBANA	ΪĹ	OH:		FL	1544	900	1.389.60	14.900.00
12	URBANA			CHICAGO	IL	1544	125	193.00	3,275.00
ΪĬ	URBANA	=======================================	IN	BLOOMINGTON	IN	1544	113	174.47	3,095,00
IN			Ϋ́	MILWAUKEE	WI	56	211	11.32	1.327.50
	INDIANAPOLIS	IN	Œ	COLUMBUS	CH	1544	158	259.39	3.920.00
10	IOWA CITY	ĽΆ	I:_	UREANA	::	1544	202	311.89	4.430.00
II	ITHACA	N':	NY.	NEW YORK	NY	1544	195	301.08	4.325.00
IT	ITHACA	NY	N7/	NEW YORK	NY	1544	195	301.08	4,325.00
IT	ITHACA	NY	ЖY	NEW YORK	NY	1544	195	301.08	
IT	ITHACA	NΥ	DC	WASHINGTON	DC DC	1544			4.325.00
	ITHACA	NY	PT	PITTSBURGH	PA	1544	291	449.30	5.765.00
KS.	KANSAS CITY	:::5	•	LIVEPMOPE	CA CA		267	412.25	5.405.00
KS	KANSAS CITY	KS		LIVERMORE		56	1.446	30.98	4.415.00
KS	KANSAS CITY	1.3 1.3	AE		CA.	1544	1.44€	2.232.52	23.090.00
ĽÄ	LOS ANGELES			ALBUQUERQUE	NM	1544-	671	1.036.02	11,465.00
ĽA	LOS ANGELES	- CA	AB	LOS ALAMOS	NM	1544	664	1,025.22	11.350.00
<u>-</u>	ANGELES	CA.	HN	HUNTSVILLE	AL.	56	1.798	100.69	5.295.00

LA	LOS ANGELES	Œ	30	SAN DIEGO	CA	56	113	5.33	1.082.50
:A:	LUS ANGELES	CΆ	30	SAN DIEGO	CA.	56	113	6.33	1,082.50
i.a	LIS ANGELES	CA.	SF	SAN FRANCISCO	CA.	1544	35C	540.40	6,650.00
ĽA	LOS ANGELES	ΩA	HU	HOUSTON	TX	56	1.376	77.06	4.240.00
LA	LOS ANGELES	ZA.	ED	BOULDER	$\overset{\dots}{\infty}$	56	822	46.03	2,855.00
ΞÄ	LOS ANGELES	ĞĂ.	50	SAN DIEGO	~~~	1544	113	174.47	3.095.00
	LOS ANGELESO	- GA	SF	SAN FRANCISCO	Œ.	1544	350	540.40	6.650.00
	FASADENA	œ.	71.	TUCSON	AZ	56	444	24.86	1.910.00
4444444444	FASADENA	OĀ.	DC	BALTIMORE	MD	56	2.292	128.35	6.530.00
	PASADENA	GĀ.	HL'	HOUSTON ISLAND		168	1,376	231.17	
7.3	PASADENA	GĀ.	DC	WASHINGTON	DC	572	2,292		10,544.00
	LINCOLN	NE.	II.	URBANA		572 56		1.540.22	35.780.00
	LINCOLN	NE NE			IL		447	25.03	1.917.50
	LINCOLN		KS	LAWRENCE	KS	56	199	11.14	1,297.50
		NE	IO	IOWA CITY	IA.	56	274	15.34	1.485.00
	LINCOLN	ΝE	BD	BOULDER	∞	1544	454	700.98	8,210.00
	LIVERMORE	ŒΑ	SF	CAKLAND	CA	56	36	2.02	8 90 .00
u.L	LIVERMORE	Œ	PR	PRINCETON	IJ	1544	2.507	3,870.81	39.005.00
	LIVERMORE	CA.	ĽA.	LOS ANGELES	CA	56	321	17.98	1.602.50
	LIVERMORE	Œ	AΒ	ALBUQUERQUE	NM	1544	860	1,327.84	14.300.00
ΜĒ	MINNEAPOLIS	MN	IO	IOWA CITY	LA	1544	243	375.19	5.045.00
MP	MINNEAPOLIS	MN	MD	MADISON	WI	1544	232	358.21	4.880.00
NF	NORFOLK	VA	TL	TALLAHASSEE	FL	1544	635	980.44	10,925.00
NY	LONG ISLAND	NY	BO	CAMBRIDGE	MA	1544	188	290.27	4,220.00
NY	NEW YORK	NY	IT	ROME	NY	1544	195	301.08	4.325.00
⊃R	CAK RIDGE	IN	CH	CHICAGO	IL	1544	441	680.90	8.015.00
OR	OAK RIDGE	IN	TL	TALLAHASSEE	FL	1544	385	594.44	7.175.00
PR	PRINCETON	NJ	TU	TUCSON	AZ	1544	2,080	3.211.52	32.600.00
PR	PRINCETON	NJ	NF	NORFOLK VA	DC	1544	269	415.34	5,435.00
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544	40	61.76	2,000.00
PR	PRINCETON	ŊJ	CH:	CHICACO	IL	1544	686	1.059.18	11.690.00
PR	PRINCETON	ŊJ	NY	LONG ISLAND	NY	1544	40	61.76	2.000.00
PR	PRINCETON	ŊJ	SD	BOLDER	œ	1544	1.610	2,485.84	25.550.00
PR	PRINCETON	ŊJ	SC	STATE COLLEGE	PA	1544	175	270.20	4.025.00
PP	PRINCETON	NJ	ΡΉ	PHILADELPHIA	PA	1544	42	54.85	2,030,00
PP.	PRINCETON	NJ	BO	CAMBRIDGE	MA	1544	229	353.58	4.835.CC
PP	PRINCETON	ŊJ	BO	CAMBRIDGE	MA	1544	229	353.58	4,835.00
PR	PRINCETON	NJ	NY	NEW YORK	NY	1544	40	61.76	2.000.00
FR	PRINCETON	NJ	NY	NEW YORK	NY.	1544	40	61.76	2.000.00
PR	PRINCETON	υ. U.	5 0	NEW HAVEN	<u>∵:</u>	1544	229	353.58	4.835.00
FP	PRINCETON	NJ	30 30	AMHERST	MA	1544	229	353.58	
2	FITTSBURGH	PA	5C	STATE COLLEGE	PA	1544	115	177.55	4.835.00 3.125.00
FT FT PT	PITTSBURGH	PA	25	PRINCETON	NJ	1544	285	440.04	
D-T	PITTSBURGH	PΑ	ΪĹ	UREANA	IL	1544	434		5.675.00
 Эт	PITTSBURGH	PA.	ć.	CLEVELAND	CH			670.10	7.910.00
27	PITTSEURGH	PA	PH	PHILADELPHIA	PA	1544 1544	114	176.02	3.110.00
PT PT PT	PITTSBURGH	PA	DC	WASHINGTON	DC DC		258	398.35	5,270,00
20	SAN DIECO	-Ω -ΩΑ	ĽA	LOS ANGELES	SA SA	1544	190	293.36	4,250.00
25	SAN DIEGO	ΞÃ.	iA			1544	113	174.47	3.095.00
3D 3D 3D	SAN DIEGO	CA CA		RIVERSIDE	CA ~	56	113	5.33	1,082.50
30 50	SAN DIEGO		LA.	LOS ANGELES	CX	1544	113	174.47	3,095.00
3D		CA.	LA	LOS ANGELES	ΩA.	1544	113	174.47	3.095.00
	SAN DIEGO	ÇA ≃	HT.	HOUSTON	TΧ	1544	1.305	2.014.92	20,975 .00
SD SD	SAN DIECO	<u> </u>	SF 	MENTLO PARK	ΩA.	1544	463	714.87	8,345.00
32	SAN DIECO	Œ.	٠.	SANTA BARBAPA	CA.	56	113	5.33	1.082.50

sum						146824	133.734	85.529.58	1.417.122.00
WI	WALLOPS ISLAND	VA	HU	HOUSTON	TX	224	1.265	283.36	12.752.50
WI	WALLOPS ISLAND	VA	MD	MADISON	WI	224	809	181.22	8,876.50
WI	WALLOFS ISLAND	VΆ	HU	HOUSTON	TX	1544	1,265	1.953.16	20.375.00
SL	SALT LAKE CITY	UT	CH	CHICACO	IL	1544	1,256	1,939.26	20,240.00
SL	SALT LAKE CITY	UT	BD	BOULDER	∞ .	1544	351	541.94	6.665.00
SL	SALT LAKE CITY	UT	SF	MENLO PARK	CA.	1544	598	923.31	10.370.00
SF	SAN FRANCISCO	CA.	CH	CHICAGO	IL	1544	1.852	2,859.49	29,180.00
SF	SAN FRANCISCO	CA	DC	WASHINGTON	C	56	2,432	136.19	6,880.00
SF	SAN FRANCISCO	CA	LA	LOS ANGELES	CA.	56	350	19.60	1.675.00
SF	SAN FRANCISCO	Œ	DC.	WASHINGTON	DC	336	2,432	817.15	33,200.00
SF	SAN FRANCISCO	Œ	BD	BOULDER	∞	56	932	52.19	3.130.00
SF	SAN FRANCISCO	CA	LL	LIVERMORE	CA.	1544	36	55.58	1.940.00
SF	SAN FRANCISCO	CA	LA	PASADENA	CA.	448	350	156.80	6,650.00
SE	SEATTLE	w A	PO	EUGENE	OR	56	147	8.23	1.167.50
SE	SEATTLE	WΆ	PO	CORVALLIS .	OR.	56	147	8.23	1,167.50
SE	SEATTLE	WA	PO	PORTLAND	OF:	56	147	8.23	1.167.50
SE	SEATTLE	WA.	SF	MENLO PARK	CA.	1544	584	1.056.10	11.550.00
SE	SEATTLE	XZ.	SD	SAN DIEGO	CA	1544	1.068	1.548.99	17.420.00
92	SAN DIEGO	æ	SL	SALT LAKE CITY	UT	56	524	34.94	2.350.00
SI	SAN DIEGO	Æ	S.L	SALT LAKE CITY	UI	56	624	34.94	2.350.00
SE	SAN DIEGO	CA.	LA	IRVINE	CA.	56	113	6.33	1.082.50
SD	SAN DIEGO	CA	SF	CAKLAND	CA	56	463	25.93	1.957.50
SD	SAN DIEGO	∴ZA	SE	SEATTLE	WA.	56	1.069	59.81	3,470,00

1991 PROJECTED COST

ID	CITY - A	ID		<u> </u>	ST	CAPACITY (KE:	MILES	M 24	COST
AB	ALEUQUERQUE	NM		LIVERMORE	CA.	56	86C	48.16	2,950.00
AΕ	ALBUQUERQUE	NM	11	LIVERMORE	<i>-</i> 25	1544	860	1.327.84	14.300.00
AB	ALBUQUERQUE	NM		KANSAS CITY	Y.S	56	671	37.58	2.477.50
AB	ALEUQUERQUE	MM	KS	KANSAS CITY	Y.S	56	671	37.58	2,477.50
AΞ	ALEUQUERQUE	NM	KS	KANSAS CITY	KS	56	671	37.58	2.477.50
AΒ	ALBUQUERQUE	NM	LL	LIVERMORE	ĊΆ	56	860	48.16	2.950.00
AB	LOS ALAMOS	NM	AU	AUSTIN	īX.	56	615	34.44	2.337.50
AB	LOS ALAMOS	NM	KS	LAWRENCE	KS	56	671	3 7.58	
AB	LOS ALAMOS	NM	ED	BOULDER	ω.	56	346	19.38	2,477.50
AU	AUSTIN	IX	DL	RICHARDSON	\widetilde{x}	1544			1,565.00
BD	BOULDER	$\tilde{\varpi}$	MD	MADISON	WI		180	277.92	4.100.00
BD	BOULDER	$\frac{3}{8}$	DC	WASHINGTON		224	844	189.06	9.174.00
BD	BOUTLDER	$\frac{\omega}{\omega}$	SL		∞	224	1,501	336.22	14,758.50
BD	BOUTLDER	8		SALT LAKE CITY	UI	56	351	19.66	1,577.50
3D			DC DC	WASHINGTON	DC	224	1,501	336.22	14.758.50
	BOULDER	∞	ВО	WOODS HOLE	MA	224	1.772	396.93	17.062.00
3D	BOULDER	∞	MI	MIAMI	FL	224	1,742	390.21	16.807.00
BD	BOULDER	∞	IJ	TUCSON	AZ	56	619	34.66	2.347.50
BD	BOULDER	∞	DT	ann arbor	MI	224	1.162	250.29	11.877.00
BD	BOUTLDER	∞	PO	CORVALIS	OR	1544	957	1,477.61	15,755.00
BD	BOULDER	∞	PC	CORVALLIS	OR	224	957	214.37	10.134.50
BD	DENVER	∞	LA	LOS ANGELES	CA.	1544	822	1,269.17	13.730.00
B O	BOSTON	MA	NY	NEW YORK	NY	1544	188	290.27	4.220.00
ВО	CAMERIDGE	MA	PP.	PRINCETON	NJ	1544	229	353.58	4,835.00
CH	CHICACO	IL	SE	SEATTLE	WA	44M	1.733	77.527.49	158,970.00
CH .	CHICAGO	IL	DT	LANSING	MI	1544	237	365.93	
CH.	CHICAGO	IL	DT	LIICHFIELD	MI	1544	237	365.93	4.955.00
CH:	CHICACO	IL	SF	SAN FRANCISCO	ĠĀ.	56	1.852		4.955.00
CH:	CHICAGO	IL	MD	MADISON	MI.	1544	121	103.71	5.430.00
CH CH	CHICAGO	IL	BD	DENVER	æ	44M	927	186.82	3.215.00
CH CH	CHICAGO	ĪĹ	TL	TALLAHASSEE	FL	56		41.470.27	86,430.00
	CHICAGO	ĪĹ	IL	URBANA	IL		806	45.14	2.815.00
	CHICACO	ĬĹ	LI	LINCOLN		1544	125	193.00	3.275.00
	CHICAGO	IL	BC	CAMBRIDGE	NE	44M	475	21,249.60	45.750.00
	WASHINGTON	$\stackrel{12}{\infty}$	NY		MA	1544	848	1,309.31	14,120.00
	Washington	DC		NEW YORK	NY	1544	205	316.52	4,475.00
			AΒ	ALBUQUERQUE	NM	56	1.646	92.18	4.915.00
	WASHINGTON	DC		LIVERMORE	CA.	56	2.401	134.46	5.902.50
	WASHINGTON	∞	LL	LIVERMORE	CA.	56	2.401	134.46	5.802.50
	WASHINGTON	ρĊ	ΞΞ	LIVERMORE	CA.	56	2.401	134.46	5.802.50
	Washington	5/3	HN	HUNTSVILLE	AL	56	60:	33.66	2.302.50
	Washington	DC	HU	HOUSTON	TK	54	1,217	58.15	3.842.50
	Washington	DC	WI	WALLOPS ISLAND	VA.	55	106	5.94	1.065.00
	Washington	DC	WI	WALLOPS ISLAND	VA	1544	106	153.66	2,990.00
	WASHINGTON	DC	<u> </u>	CLEVELAND	OH	112	304	34.05	2.568.00
DC 1	Washington	DC	KN	CAPE KENNEDY	FL	168	760	127.68	6.540.00
	MASHINGTON	DC	LA	LOS ANGELES	ĊΆ	56	2.292	128.35	5.530.30
DC W	MASHINGTON	DC	WS	WHITE SANDS	NM	224	1,571	352.13	
	VASHINGTON	20	WS	WHITE SANDS	NM.	56	1.572		15.362.00
√. W	VASHINGTON	D.C	LA	BARSTOW	CA.	224	2.292	88.03	4.730.00
ic w	VASHINGTON	5c	LA.	BARSTOW	Œ.	56	74	513.41	21.482.00

2:0		EX	с з о	CAMBRIDGE	MA	56	394	22.06	1.785.30
50	Washington	DX	J PR	PRINCETON	ŊJ	4 4M	165	7.381.44	17,850.00
D:0	WASHINGTON	Do	C SF		CA.	1544	2,432	3.755.01	
DC	WASHINGTON	DX	S SF	SAN FRANCISCO	ČA.	112			37.880.00
∞		DX					2.432	272.38	12.144.00
50	WASHINGTON	50			ĊΑ.	224	2.432	544.77	22.672.00
~	WASHINGTON	DC			ĪΧ	4 4M	1,217	54.443.71	112,530.00
50 50 50 50	WASHINGTON				ÇA	448	2,292	1.026.82	35,780.00
		DC			CA.	280	2.292	541.76	26,466.00
7,7	WASHINGTON	DC		LOMPOC	CA	224	2,292	513.41	21.482.00
50 50	WASHINGTON	DC		HUNTSVILLE	AL	1544	601	927.94	10,415.00
55	WASHINGTON	∞		CAFE KENNEDY	FL	672	760	510.72	12.800.00
DC	WASHINGTON	DC		HUNTSVILLE	AL	512	601	307.71	10.415.00
DC	WASHINGTON	DC	HU.	HOUSTON	TX	56	1.217	68.15	3.842.50
DC	WASHINGTON -	DC	HU	HOUSTON	ĪΧ	2048	1,217	2.492.42	
ЭC	WASHINGTON	DC	PH	WILMINGTON	DE	56			29,482.50
DC	WASHINGTON	DC		NORFOLK	VA	56	124	6.94	1.110.00
DC	WASHINGTON	DC		HOUSTON	ΪX	56	157	8.79	1,192,50
DC	WASHINGTON	DC		CAPE KENNEDY			1,217	68.15	3,842.50
ĎĊ	WASHINGTON	DC DC			FL	280	760	212.80	10.380.00
Ď	WASHINGTON	DC		NEW YORK	NY	56	205	11.48	1,312.50
55			W _	WALLOPS ISLAND		56	106	5.94	1,065.00
5.5	RICHARDSON	TX		TALLAHASSEE	FL	1544	754	1.164.18	12,710.00
27	ANN ARBOR	MI	Œ	CLIMBUS	OН	1544	163	251.57	3.845.00
	ANN ARBOR	MI		PRINCETON	NJ	4 4M	459	20.533.82	44.310.00
HN	HUNTSVILLE	AL	KN:	CAPE KENNEDY	FL	2048	563	1.153.02	14.757.50
HN	HUNTSVILLE	AL	HU	HOUSTON	TX	168	616	103.49	
HN	HUNTSVILLE	AL	DC	WASHINGTON	DC	672	501		5,604.00
HN	HUNTSVILLE	AL	EN	ORLANDO	FL	56		403.87	10.415.00
HN	HUNTSVILLE	AL	MI	MIAMI	FL	56 56	563	31.53	2,207.50
HU	BRYAN	TX	AU	AUSTIN			722	40.43	2,605.00
HU	HOUSTON	ΪX	DL		TX	1544	147	226.97	3,605.00
HU	HOUSTON	TX		DALLAS	TX	56	224	12.54	1,360.00
HU	HOUSTON		HN	HUNTSVILLE	AL	56	616	34.50	2,340.00
HU		TX	WS	WHITE SANDS	NM	56	500	28.00	2.050.00
	HOUSTON	TX	AL	AUSTIN	TX	1544	147	226.97	3.605.00
HĽ	HOUSTON	TX	ΑU	AUSTIN	TX	56	147	8.23	1.167.50
HĽ.	HOUSTON	ΤX	BD	BOULDER	∞	4.4M	899	40.217.66	83.910.00
HĽ.	HOUSTON	TX	ΑĽ	AUSTIN	TΧ	56	147	8.23	1,157.50
HU IL	HOUSTON	TΧ	KIN.	CAPE KENNEDY	FL	1544	900	1.389.60	
IL	URBANA	IL	CH:	CHICACO	IL	1544	125		14,900.00
	UR BANA	IL	IN	ELOCIMINGTON	IN	1544		193.00	3.275.00
ΞΞ.	URBANA	IL	MI	MILWAUKEE	WI.	56	113	174.47	3,095.00
IN:	INDIANAPOLIS	IN	Œ	COLUMBUS .	CH.	1544	211	11.82	1.327.50
	IOWA CITY	ĪΑ	71	URBANA	IL		168	259.39	3,920.00
	ITHACA	NY	N.	NEW YORK		1544	202	311.89	4.430.00
	ITHACA	NY	:57	NEW YORK	NY	1544	195	301.09	4.325.00
	ITHACA	NY	NT:		MY	1544	195	301.08	4.325.00
	ITHACA	71.		NEW AOUR	MY	1544	195	301.08	4.325.00
	ITHACA	-	<u> </u>	Washington	33.	4.4M	291	13.018.18	29.190.00
F.3		МĀ	PT	PITTSBURGH	PA	44M	267	11.944.51	27.030.00
! ::-	HANSAS CITY	KS	Ľ	LIVEPMORE	CA.	56	1,446	30.98	4.415.00
KS	MANSAS CITY	KS		LIVERMORE	CA	1544	1.446	2.232.52	23.090.00
:5	KANSAS CITA	KS	ΑΞ	ALBUQUERQUE	124	1544	571	1.036.02	
LA	LOS ANGELES	CA	ΑE	LOS ALAMOS	NM	1544	564		11.465.00
LA	LOS ANGELES	CA	H21	HUNTSVILLE	ÀL.	56		1.025.22	11.360.00
ĽA.	LOS ANGELES	CA	52	SAN DIEGO	Ġ.	56	1.798	100.69	5,295.00
				3.2. DILOV	∽ ∧	20	113	6.33	1.082.50

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LA	LOS ANGELES	7	. SD	SAN DIEGO	CΑ	56	113	6.33	1.082.50
LA	LOS ANGELES			SAN FRANCISCO	Œ.	1544	350	540.40	6.650.00
LA	LOS ANGELES	Ğ.		HOUSTON	TM:	56	1.376	77.06	4.240.00
LA	LOS ANGELES	Ğ,		SOULDER	\tilde{x}	56	822	46.03	
LA	LOS ANGELES	ÇA ÇA		SAN DIEGO	∝ ŒA	1544			1.355.00
LA	LOS ANGELESO	ŒA ŒA		SAN FRANCISCO			113	174.47	3.095.00
LA	PASADENA	CA CA	•	TUCSON	ΩA NA	1544	350	540.40	5.550.CO
LA	PASADENA	GA CA		EALTIMORE	AZ	56	444	24.86	1.910.00
LA	PASADEID.	CA CA		HOUSTON ISLAND	MD	56	2.292	128.35	5.530.00
ĽÀ	PASADENA	CA CA				168	1.376	231.17	13,544.00
LI	LINCOLY	NE NE		WASHINGTON	DC.	672	2.292	1.540.22	35,780.00
LI	LINCOLN			URBANA	IL	56	447	25.03	1,917.50
LI		NE		LAWRENCE	KS	56	199	11.14	1.297.50
	LINCOLN	NE		IOWA CITY	ΙA	56	274	15.34	1,485.00
LI	LINCOLN	NE	BD	BOULDER	∞	4 4M ·	454	20.310.14	43.860.00
LL	LIVERMORE	CA	SF	CAKLAND	CA.	56	36	2.02	390.00
LL	LIVERMORE	CA	PR	FRINCETON	NJ	1544	2.507	3.870.81	39.005.00
ഥ	LIVERMORE	CA.	LA	LOS ANGELES	CA	56	321	17.98	1.502.50
LL	LIVERMORE	CA.	AB	ALEUQUERQUE	NM	1544	860	1.327.84	14.300.00
MP	MINNEAPOLIS	MN	IO	IOWA CITY	LA	1544	243	375.19	5.345.00
MP	MINNEAPOLIS	MN	M	MADISON	WI	1544	232	358.21	4.880.00
NF	MORFOLE:	VA.	TL	TALLAHASSEE	FĹ	1544	635	980.44	10.925.00
N'ı	LONG ISLAND	NY	BO	CAMERIDGE	MA	1544	198	290.27	4.220.00
NY	NEW YORK	NY	IT	ROME	NY	1544	195	301.08	4.325.00
OR.	OAK RIDGE	IN	CH	CHICACO	IL	1544	441	680.90	9.015.00
OR	CAK RIDGE	IN	TL	TALLAHASSEE	FL	1544	385	594.44	7.175.00
PR	PRINCETON	NJ	TU	TUCSON	ΑŽ	1544	2.980	3,211.52	32,600.00
PR	PRINCETON	NJ	NE	NORFOLK VA	DC	1544	259	415.34	
PR	PRINCETON	ŊJ	NY	NEW YORK	NY	1544	40	61.76	5.435.00
PR	PRINCETON	NJ	αн	CHICAGO	IL	1544	586	1.059.18	2,000.00
PR	PRINCETON	NJ	NY	LONG ISLAND	NY	1544	40		11.690.00
PR	PRINCETON	NJ	BD	BOLDER	<u>α</u>	1544	1.610	61.76	2.000.00
PR	PRINCETON	NJ	SC	STATE COLLEGE	oo PA	1544		2.485.84	25.550.00
PR	PRINCETON	ŊJ	PH	PHILADELPHIA	PA	1544	175	270.20	4.025.00
PF	PRINCETON	NJ	80	CAMBRIDGE	MA.		42	64.85	2,030.00
ep.	PRINCETON	NJ	BO	CAMERIDGE		1544	229	353.58	4.835.00
PP.	PRINCETON	NJ	NY		MA	1544	229	353.58	4.835.00
PD	PRINCETON	NJ NJ	NY NY	NEW YORK	NY	1544	40	61.75	2.000.00
PE	PRINCETON	NJ NJ	PC	NEW YORK	NY	1544	40	61.76	2.000.00
PP.	PRINCETON	UN UN		NEW HAVEN	CI.	1544	229	353.58	4.835.00
PŢ	PITISBURGH	PA	BO SC	AMHERST	MA	1544	229	353.58	4.835.00
PT	PITTSBURGH			STATE COLLEGE	PA	1544	115	177.56	3.125.00
PT	PITTSBURGH	FA	PP.	PRINCETON	NJ	4 4M	285	12.749.76	18.55C.OC
 		PA	<u> </u>	URBANA	IL	4 4M	434	19.415.42	42.360.00
	PITTSEURGH	FA	Ξ.	CLEVELAND	OH:	1544	114	175.02	3.110.00
PT.	PITTSBURGH	PA	PH	PHILADELPHIA	PΑ	1544	258	398.35	5.270.00
PT	PITTSBURGH	PA	2.7	Washington	D/C	1544	. 190	293.35	4.250.00
32	SAN DIEGO	Œ	ĿA	LOS ANGELES	CA.	1544	113	174.47	3,095.00
SD	SAN DIEGO	CA	LA	RIVERSIDE	CA.	56	113	5.33	1,082.50
SD	SAN DIEGO	GA.	LA	LOS ANGELES	GA.	1544	113	174.47	3.095.00
SD	SAN DIEGO	₹	LA	LOS ANGELES	CA	1544	113	174.47	3.095.00
SD	SAN DIEGO	CA.	HU	HOUSTON	TX	4 4M	1.305	58,380.48	120,450.00
3D	SAN DIEG:	CA	SF	MENTLO PAPY.	CA	4 4M	463	20.712.77	44.670.00
SD	SAN DIEGO	\Im A	ĽΑ	santa earbara	ΩA.	56	113	6.33	1.082.50
SD	SAN DIEGO	\simeq	SE	SEATTLE	WA	55	1,058	59.81	3,470.00
								-	

sum							133.385	661,302.57	2,446,474.5C
			nu	TOO TON	IX	224	1,265	283.36	12,752.50
WI	WALLOPS ISLAND	VA.	HU	MADISON HOUSTON	WI	224	809	181.22	8,876.50
WI	WALLOPS ISLAND	VA.	MD		ΤX	1544	1.265	1.953.16	20,375.00
WI	WALLOPS ISLAND	VA	∪n HU	HOUSTON	IL	4.4M	1.256	56,188,42	115.040.00
SL	SALT LAKE CITY	UT	CH CH	CHICAGO	∞	4 4M	351	15.702.34	34,590.00
SL	SALI LAKE CITY	LT	BD	MENILU PARK BOUTLDER	CA	4 4M	598	26,752.13	56.820.00
SL	SALT LAKE CITY	UI.	SF	CHICAGO MENLO PARK	IL	1544	1.852	2.859.49	29.180.00
SF	SAN FRANCISCO	CA CA	DC CH	WASHINGTON	ΣC	56	2.432	136.19	6.880.00
SF	SAN FRANCISCO	Š		LOS ANGELES	CA.	56	350	19.60	1.575.00
SF	SAN FRANCISCO	CZ CZ	DC LA	WASHINGTON	$\overline{\mathbb{C}}$	335	2.432	817.15	33,200.00
SF	SAN FRANCISCO	CA CTA	B D	BOULDER	∞	56	932	52.19	3.130.00
SF	SAN FRANCISCO	CA C3		LIVERMORE	CA	1544	35	55.58	1,940.00
SF	SAN FRANCISCO	CA CT	LA.	PASADENA	Œ	448	350	156.80	6,650.00
3E	SEATTLE SAN FRANCISCO	WA	PC	EUGENE	OR.	56	147	8.23	1.167.50
SE SE	SEATTLE SEATTLE	WA	Ρŷ	CORVALLIS	OF.	56	147	8.23	1.167.50
SE	SEATTLE	WA	PO	PORTLAND	ÛΕ	56	147	8.23	1,167.50
SE SE	SEATTLE	WA	SF	MENLO PAPI	CP.	4 4M	684	30,599.42	64.560.CC
SE	SEATTLE	WA	SD	SAN DIEGO	CA.	4 4 M	1,068	47.778.05	99,120,00
SD	SAN DIEGO	CA	SL	SALT LAME CITY	UT	56	624	34.94	2,360.00
SD	SAN DIEGO	CA	S.T	SALT LAKE CITY	UI	56	624	34.94	2,360.00
SD	SAN DIECO	ÇĀ,	LA	IRVINE	CA.	56	113	6.33	1,082.50
SD	SAN DIEGO	CA	SF	CAKLAND	CA	56	463	25.93	1,957.50

3.6.3 1996 IRN Circuit Costs

The cost per month for each city-pair link and for the total 1996 IRN are shown in Exhibit ES-22. The city-pairs are listed in the same order as they were listed in earlier exhibits listing the 1996 IRN links.

The total 1996 IRN monthly cost of about eight and one-half million MMs was estimated to be about 6 million dollars. That is, compared with 1991, about thirteen times as much traffic is expected to be moved for only about two and one-half times the 1991 cost.

3.6.4 2000 IRN Circuit Costs

The circuit costs per month for each city-pair link and for the total 2000 IRN are shown in Exhibit ES-23. The city-pairs are listed in the same order as they were listed in earlier exhibits listing the 2000 IRN links and as they were listed in Exhibit ES-22 which showed the 1996 costs.

The total 2000 IRN monthly cost of about 35 million MMs was estimated to be about 16 million dollars. That is, compared with 1996, about four times as much traffic is expected to be moved in 2000 for about two and one-half times the 1996 cost.

3.6.5 2010 IRN Costs

The circuit costs per month for each city-pair link and for the total 2010 IRN are shown in Exhibit ES-24. The city-pairs are listed in the same order as they were listed in earlier exhibits listing the 2010 IRN links and as they were listed in Exhibit ES-23 which showed the 2000 costs.

The total 2010 IRN monthly cost of about 162 million MMs was estimated to be about 29 million dollars. That is, compared with 2000, about four and one-half times as much traffic is expected to be moved for less than two times the 2000 cost.

1996 PROJECTED COST

ID	CITY - A	ST	ID	CITY - B	ST	CAPACITY	MILES	₩.	œsī
AB	ALBUQUERQUE	NM	HU	HOUSTON	TX	5 6 5M	754	426,010.00	343.800.0
AT	atlanta	GA	∞	COLUMBIA	SC	90M	193	17,408.60	34,766.0
AT	ATLANTA	GA	TL	TALLAHASEE	FL	90 M	233	21.016.60	41,245.0
AU	AUSTIN	TX	コエ	CALLAS	TΧ	90M	180	16,236.00	32,660.0
BD	90ULDER	∞	AB	ALEUQUERQUE	NM	90M	346	31,209.20	59,552.0
BD	BOULDER	∞	3F	SAN FRANCIS ∞	ŒA	!G	932	1.053.160.00	508,280.0
BI	BILLINGS	MI	○.	CHEYENNE	WY	90M	368	33,193.60	63.116.0
BI	BILLINGS	MI	FR	FARGO	ND	90M	565	50,963.00	95.030.0
BO	BOSTON	MA	NY	NEW YORK	NY	ig	297	335.610.00	155,380.0
CB	COLUMBUS .	OН	DT.	DETROIT	MI	9CM	163	14.702.60	29,906.0
CH	CHICACO	IL	31 31	URBANA	IL	1G	125	141,250.00	72.500.0
CH	CHI CACO	IL	OR.	OAK RIDGE	IN	56 5M	441	249.165.00	202,950.0
CH	CHICAGO	IL	LI	LINCOLN	NE	IG	475	536,750.00	261,500.0
CH	CHI CACO	IL	DT	DETROIT	MI	90M	237	21.377.40	41.894.0
CH	CHICAGO	IL	ST	ST LOUIS	MO	9QM	260	23,452.00	45.620.0
α L	CLEVELAND	OH	CB	COLUMBUS .	OH	90M	126	11,365.20	23,912.0
∞	COLLIMBIA	SC	RL	RALEIGH	NC	90 M	183	16.506.60	33.146.0
CY	CHEYENNE	WY	BD	BOULDER	æ	9CM	. 80	7.216.00	15.450.0
DC	WASHINGTON	DC	PT	PITTSBURGH	PA	IG.	190	214,700.00	107.600.0
DC	WASHINGTON	DC	NF	NORFOLK	VA	565M	157	88,705.00	75,150.0
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	90M	106	9,561.20	20,672.0
FR	FARGO	ND	MP	MINNEAPOLIS	MN	90M	214	19.302.80	38.168.0
Æ	HELENA	MI	BI	BILLINGS	MI	9 0M	178	16.055.60	32.336.3
HN	HUNTSVILLE	AL	OR.	CAK RIDGE	TN	90M	162	14,612.40	29,744.0
-TU	HOUSTON	ΤX	OR.	OAK RIDGE	ĪN	565M	777	439.005.00	354,150.0
-TU	HOUSTON	ΪX	NO	NEW ORLEANS	LA	90M	320	28,864.00	55,340.0
IN	INDIANAPOLIS	IN	CH:	CHICAGO	IL	90M	164	14.792.80	30.068.0
IT	ITHACA	NY	NY	NEW YORK	NY	1G	195	220.350.00	110.300.0
QΝ	KENNEDY SPC CIT		MI	MIAMI	FL	90M	176	15,875.20	32.012.0
LÀ.	LOS ANGELES	`` ČĀ	SD	SAN DIECO	ĆĀ	16	113	127,690.00	66.020.0
Ξ.	LINCOLN	NE	HU	HOUSTON	TX	1G 1G	759	857,670.00	414.860.0
ī	LINCOLN	NE	BD	BOULDER	æ	1G 1G	454	513,020.00	250,160.0
I	LINCOLN	NE	IO	IOWA CITY	IA	90M	274	24,714.80	47,888.0
	MADISON	WI	CH .	CHICAGO	IL	565M	121	68.365.00	58,950.0
4P	MINNEAPOLIS	MN	MD	MADISON	WI	565M	232	131,080.00	108,900.00
, io	NEW ORLEANS	LA	TL	TALLAHASEE	FL	90M	348	31,389.60	59,876.00
īY	NEW YORK	NY	œ	WASHINGTON	DC	1G	236	266.680.00	132,440.00
JY	NEW YORK	NY	» PI	PITTSBURGH	PA	1G 1G	207		
XR.	OAK RIDGE	TN	TL.	TALLAHASEE	FL	565M	385	233.910.00	116,780.0
Ô	PORTLAND	OR	SE	SEATTLE	WA.	90M	147	217,525.00	177.750.0
T	PITTSBURGH	PA	ar 35	CLEVELAND		90M	114	13,259.40	27,314.0
Ť	PITTSBURGH	PA	CH.	CHICACO	OH IL	IG	409	10,282.80	21,968.09
Ĺ	RALEIGH	NC	NF.	NORFOLK	VA	90M	149	462,170.00	225.860.0
č	STATE COLLEGE	PA	PT	PITTSBURGH	PA	90M		13.439.80	27,638.00
D D	SAN DIEGO	<u>α</u>	AB	ALBUQUERQUE		90m 565M	115	10.373.00	22.130.00
E	SEATTLE	WA.	ΉE	HELENA	NM NT		623	351.995.00	284.850.00
Ē	SEATTLE	WA.	SF		MI	90M	489	44.107.80	82.718.00
E F		CA.		SAN FRANCISCO	CA.	565M	684	386,460.00	312.300.00
r F	SAN FRANCISCO SAN FRANCISCO	5 A	LL	LIVERMORE	CA.	IG	36 350	40.680.00	24.440.00
r L			LA	LOS ANGELES	CA.	1G	350	395,500.00	194.000.00
	SALT LAKE	UT.	BD	BOULDER	8	90M	351	31.660.20	60.362.00
Ţ	ST LOUIS	MO	K.S	KANSAS CITY	MO	90M	269	24.253.80	47,078.00
L	TALLAHASEE	FL	KIN HIG	KENNEDY SPC CIR		565M	264	149.160.00	123.300.00
บ ——	TUCSON	AZ	WS	WHITE SANDS	NM	90M	440	39,688.00	74,780.00
m							16,166	8,533,500.00	5,919,620.00

YEAR 2000 PROJECTED COST ID CITY - A CITY - B ST ID ST CAPACITY MILES 144 COST ALBUQUERQUE AB NM ΗIJ HOUSTON TX 1G 754 852,020.00 412,160.00 ΑT ATLANTA GA **COLUMBIA** SC 565M 193 109.045.00 91.350.00 ΑT ATLANTA GA TALLAHASEF FL 565M 233 131.645.00 109,350.00 AU DL AUSTIN $\mathbf{T}\mathbf{X}$ DALLAS TΧ 565M 180 101,700.00 85,500.00 BD BOULDER ALBUQUERQUE ∞ AB NΜ 565M 346 195,490.00 160.200.00 BD BOULDER α SF SAN FRANCISCO CA 5G 5,055,168.00 932 2.021.120.00 EI ΜI CY BILLINGS CHEYENNE WY 565M 207.920.00 368 170,100.00 BILLINGS ΒI MI FR FARGO ND 565M 565 319,225.00 258,750.00 ВО BOSTON ΜA ΝY NEW YORK NY 5G 297 1.510,928.00 649.520.00 DT IL Œ **CLIMBUS** DETROIT MI 565M 163 92,095.00 77.850.00 CH CHICAGO URBANA IL 5G 125 678,000.00 278,000.00 CH CHICAGO OR. OAK RIDGE TN 1G 441 498,330.00 243.140.00 CH: CHICACO LI LINCOLN NE 5G 475 2,576,400.00 1.034.000.00 Œ: CHICAGO DI DETROIT MI 565M 237 133,905.00 111.150.00 CH CHICAGO ST ST LOUIS MO 565M 260 146,900.00 121.500.00 $C\Gamma$ CLEVELAND OH CB **WILLIMBUS** OH 565M 126 71,190.00 61,200.00 CUMBIA ∞ SC RL RALEIGH NC 565M 183 103,395.00 86.850.00 Ci, CHEYENNE WY BD BOULDER ∞ 565M 80 45,200.00 40,500.00 DC WASHINGTON DC FI PITTSBURGH PA 5G 190 1.030,560.00 418.400.00 ∞ WASHINGTON DC NE NORFOLK VA 1G 157 177,410.00 89.780.00 ∞ WASHINGTON DC WI WALLOPS ISLAND 565M VA 106 59.890.00 52,200.00 FR FARGO ND MP MINNEAPOLIS MN 565M 214 120,910.00 100,800.00 ΗE HELENA MT ΒI BILLINGS MT 565M 178 100,570.00 84,600.00 HN HUNTSVILLE AL OR OAK RIDGE TN 565M 162 91,530.00 77,400.00 ΗŪ HOUSTON ΤX OR OAK RIDGE TN 1G 777 878,010.00 424.580.00 HU HOUSTON TX NO NEW ORLEANS LA 565M 320 180,800.00 148.500.00 IN IT INDIANAPOLIS IN CH CHICAGO IL 565M 164 92,660.00 78,300.00 I THACA NY NY NEW YORK NY 5G 1,057,680.00 195 429,200.00 ΚN KENNEDY SPC CTR ΜI FI. MIAMI FL 565M 175 99.440.00 83,700.00 LA LOS ANGELES CA SD SAN DIEGO CA5G 113 612,912.00 ĹĬ 252,080.00 LINCOLN NE HU HOUSTON ĪΧ 5G 759 4,116,816.00 1,647,440.00 LI LINCOLN ΝE BD BOULDER ∞ 5G 454 2.462.496.00 988,640.00 LINCOLN NE 10 IOWA CITY ΙA 565M 274 154,810.00 127,800.00 MD MADISON WI CH CHICACO IL 1G 121 136,730.00 70.340.00 ΜP MD TL MINNEAPOLIS MN MADISON WI IG 232 262,160.00 130,280.00 NO NEW ORLEANS LA TALLAHASEE FL 565M 348 196,620.00 161.100.00 MY NEW YORK ŊŸ DC WASHINGTON ∞ 5G 236 1.280.064.00 517,760.00 NY NEW YORK NY PITTSBURGH PA 5G 207 1.122.758.00 455,120.00 OP. CAK RIDGE ΤN TALLAHASEE FL 1G 385 435,050.00 212.900.00 2 **PORTLAND** CR SEATTLE WA 565M 147 PI PI RL 83,055.00 70,650.00 PITTSBURGH CLEVELAND PA OН 565M 114 64,410.00 55.800.00 PITTSBURGH СH PA CHICAGO IL 5G 409 2,218,416.00 891,440.00 RALEIGH NC ΝF NORFOLK VA 565M 149 84,185.00 71,550.00 SC STATE COLLEGE PA PŢ PITTSBURGH PA 565M 115 64.975.00 56,250.00 SD SAN DIEGO Œ ΑB ALBUQUERQUE NM IG 623 703,990.00 341,420.00 SE SEATTLE WΑ ΗE HELENA ΜŢ 555M 489 275,285.00 SE 224.550.00 SEATTLE SF WΆ SAN FRANCISCO CA 1G 772.920.00 684 374,360.00 SF SAN FRANCISCO CA LIVERMORE CA 5G 36 195,264.00 85,760.00 SF SAN FRANCISCO CALA LOS ANGELES CA 50 350 1.898,400.00 764,000.00 SI SALT LAKE UT BD BOULDER \mathfrak{T} 565M 351 198.315.00 152.450.00 51 ST LOUIS MO Ю KANSAS CITY MO 565M 269 151,985.00 125,550.00 TALLAHASEE EN KENNEDY SPC FL 1G 264 298.320.00 147,560.00 TUCSON WHITE SANDS 565M 440 248,600.00 202,500.00 sum

EXHIBIT ES-23. 2000 IRN Circuit Costs

16,166

34.857,562.00

16.137,000.00

YEAR 2010 PROJECTED COST

ID	CITY -A	ST	ID	CITY - B	ST	CAPACITY	MILES	MM .	COST
AB	ALBUQUERQUE	NM	HU	HOUSTON	TK	5G	754	4,089.696.00	1.636.640.00
AT	ATLANTA	GΑ	∞	COLUMBIA .	SC	1G	193	218,090.00	109,220.00
AT	ATLANTA	GA	71	TALLAHASEE	FL	1G	233	263,290.00	130,820.00
AU	AUSTIN	TK	DL	DALLAS	TX	1G	180	203,400.00	102,200.00
BD	BOULDER	∞	AB	ALEUQUERQUE	NM	1G	346	390,980.00	191,840.00
BD	BOULDER	∞	5F	SAN FRANCISCO	CA	25G	932	25,275,840.00	3,029,680.00
BI	BILLINGS	MT	CY	CHEYENNE	WY	1G	368	415,840.00	203.720.001
BI	BILLINGS	MI	FR	FARGO	ND	iG	565	638,450.00	310,100.00
80	BOSTON	MA	NY	NEW YORK	NY	25G	297	8,054,640.00	972.280.00
GB	COLUMBUS COLUMBUS	CH	DT	DETROIT	ΜI	1G	163	184.190.00	93,020.00
CH CH	CHICAGO	IL	IL	URBANA	ΙL	25G	125	3.390.000.00	415.000.00
CH CH	CHICAGO	IL	OR	CAK RIDGE	IN	5G	441	2.391.984.00	960.560.00
CH CT			LI		NE	25G	475		
	CHICAGO	IL		LINCOLN			237	12.882,000.00	1.549.000.00
CH.	CHICAGO	IL	DT	DETROIT	MI	IG		267.810.00	132,980.00
ŒН	CHICAGO	IL	ST	ST LOUIS	MO	1G	260	293,800.00	145.400.00
CL.	CLEVELAND	CH	CB	COLUMBUS	OH	1G	126	142.380.00	73,040.00
∞	COLUMBIA	SC	RL	RALEIGH	NC	1G	183	206,790.00	103.820.00
CY	CHEYENNE	WY	ED	BOULDER	∞	1G	80	90.400.00	48,200.00
DC	WASHINGTON	DC	PT	PITTSBURGH	PA	2 5 G	190	5,152,800.00	625,600.30
DC	WASHINGTON	DC	NF	NORFOLK	VA	5G	157	851,568.00	347.120.00
DC	WASHINGTON	DC	WI	WALLOPS ISLAND	VA	1G	106	119,780.00	62,240.00
FR	FARGO	ND	MP	MINNEAPOLIS	MN	1G	214	241,820.00	120,560.00
ΗE	HELENA	MT	BI	BILLINGS	MT	1G	178	201.140.00	101.120.00
HN	HUNTSVILLE	AL	OR	CAK RIDGE	TN	1G	162	183,060.00	92,480.00
HU	HOUSTON	TX	OR	OAK RIDGE	TN	5G	777	4,214,448.00	1,686,320.00
HU	HOUSTON	TΧ	NO	NEW ORLEANS	LA	IG	320	361,600.00	177,800.00
IN	INDIANAPOLIS	IN	CH	CHICAGO	IL	iG	164	185,320.00	93.560.00
IT	ITHACA	NY	NY	NEW YORK	NY	25G	195	5.288.400.00	641,800.00
KN	KENNEDY SPC CTR		MI	MIAMI	FL	1G	176	198.880.00	100,040.00
LA	LOS ANGELES	ĊĀ	SD	SAN DIEGO	ĆÃ	25G	113	3,064,560.00	376,120.00
LI	LINCOLN	NE	HU	HOUSTON	ĪΧ	25G	759	20,584,080.00	2,469,160.00
LI	LINCOLN	NE	BD	BOULDER	8	25G	454	12,312,480.00	
LI	LINCOLN	NE	IO	IOWA CITY	IA		274		1,480,960.00
MD	MADISON	NE. WI				1G		309.620.00	152,960.00
		-	CH	CHICACO	IL	5G	121	656.304.00	269.360.00
MP	MINNEAPOLIS	MN	MD	MADISON	WI	5G	232	1,258,368.00	509,120.00
NO	NEW ORLEANS	LA	TL	TALLAHASEE	FL	1G	348	393.240.00	192,920.00
NY	NEW YORK	NY	DC	WASHINGTON	DC	25G	236	6,400,320.00	774.640.30
NY	NEW YORK	NY	PT	PITTSBURGH	PA	25G	207	5,613,840.00	680,680.30
OR .	CAK RIDGE	1.7/	TL	TALLAHASEE	FL	5G	385	2.088.240.00	839,600.00
P O	PORTLAND	OR.	SE	SEATTLE	WA	1G	147	166,110.00	8 4.38 0.00
PT	PITTSBURGH	PA	α	CLEVELAND	OH:	1G	114	128,820.00	66,560.00
PT	PITTSBURGH	PA	СH	CHICACO	IL	25G	409	11.092,080.00	1.335.160.00
RL.	RALEIGH	NC	NF	NORFOLK	VA.	1G	149	168,370.00	85,460.00
SC	STATE COLLEGE	PA	PΤ	PITTSBURGH	PA	1G	115	129,950.00	67.100.00
SD	SAN DIEGO	CA.	AB	ALBUQUERQUE	NM	5G	623	3,379,152.00	1,353,680.00
SE	SEATTLE	WA	ΗE	HELENA	MT	1G	489	552.570.00	269.060.00
SE	SEATTLE	WA	SF	SAN FRANCISCO	CA.	5G	684	3.710.016.00	1,485,440.00
SF	SAN FRANCISCO	CA.	LL	LIVERMORE	CA.	25G	36	976,320.00	126,640.00
SF	SAN FRANCISCO	ĊA.	LA	LOS ANGELES	ĊĀ.	25G	350	9,492,000.00	1,144,000.00
SL	SALT LAKE	UÏ	BD	BOULDER	æ	1G	351	396,630.00	194.540.00
ST	ST LOUIS	MO	KS	KANSAS CITY	MO	iG	269	303.970.00	150,260.00
77	TALLAHASEE	FL	KN	KENNEDY SPC CTR		5G	264	1.431.936.00	
īŪ	TUCSON	AZ	WS	WHITE SANDS	NM.	1G	440	497,200.00	578.240.00 242.600.00
	100001	A4.	73	WHITE SANDS	INITE		440	477.200.00	242.600.00
um							16,166	161.504.572.00	29,184,800.00

EXHIBIT ES-24. 2010 IRN Circuit Costs

3.6.6 Summary Of Circuit Costs

The monthly circuit costs and the cost per MM for each benchmark year that were discussed above are summarized in Exhibit ES-25.

In addition to providing a summary of the circuit costs discussed above, Exhibit ES-25 also presents a summary of the circuit costs for the benchmark years 1996, 2000 and 2010, assuming that the IRN does not become integrated. These additional costs were developed so that the cost implications of not integrating the IRN could be determined. These cost were developed by first applying growth rates to the individual network links in the 1991 IRN. That is, the same network links that were costed for 1989 and 1991 were costed for 1996, 2000 and 2010. For each benckmark year, a link's capacity was increased to a capacity one step above its capacity for the previous benchmark year, using the following step increases in capacity: 56 Kbps, 1.544 Mbps, 45 Mbps, 565 Mbps, 1 Gbps, and 5 Gbps. These growth projections resulted in non-integrated IRNs for 1996, 2000 and 2010 with total capacities about equal to the capacities of the integrated IRNs for 1996, 2000, and 2010.

Assuming a non-integrated IRN is 1989 and 1991 and an integrated IRN in 1996 and beyond (i.e, the expected scenario), the IRN monthly circuit cost increases from 1989 to 2010 by about a factor of 20, while the capacity increases by about a factor of 1800. That is, the cost per month per MM in 2010 is only about 1/90 of the cost in 1989. This drop in cost is diagrammed in Exhibit 1-26. The cost per MM drops from about \$16.50/MM in 1989 to about \$.18/MM in 2010.

The implications of not integrating the IRN in 1996 and beyond are diagrammed in Exhibits ES-27 and ES-28. Exhibit ES-27 shows that the non-integrated IRN cost per month per MM is about double the integrated IRN cost in 1996. It is tripple the cost in 2010. These cost implications of not integrating the IRN are dramatized even more in Exhibit ES-28. The integrated IRN monthly circuit costs are about five million dollars less than the non-integrated cost in 1996. This difference increases to about sixty million dollars in 2010.

			0.64800-68
YEAR	COST/MONTH	MMs	COST/MONTH/MM
Non-Integrated			·
1989	\$ 1,417,122.00	85,529	\$ 16.57
1991	\$ 2,446,474.00	661,302	\$ 3.70
Integrated			
1996	\$ 5,919,620.00	8,533,500	\$ 0.69
2000	\$ 16,137,000.00	34,857,562	\$ 0.46
2010	\$ 29,184,800.00	161,504,572	\$ 0.18
Non-Integrated			
1996	\$ 10,604,035.00	9,094,900	\$ 1.17
2000	\$ 20,207,500.00	37,104,024	\$ 0.81
2010	\$ 88,522,460.00	164,184,932	\$ 0.54

EXHIBIT ES-25. Summary Of IRN Circuit Cost Projections



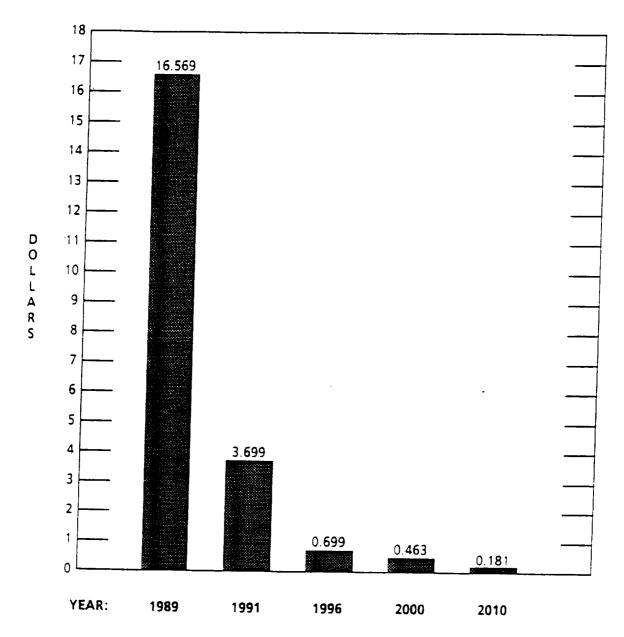


EXHIBIT ES-26. Projections Of Monthly Costs/MM

(Not integrated in 1989 & 1991; Integrated in 1996 and Beyond)

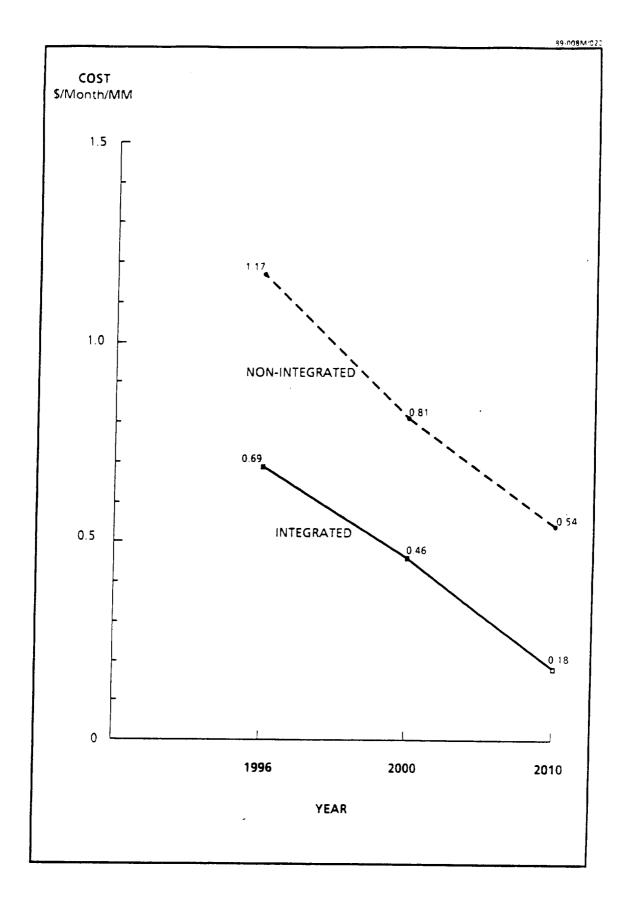


EXHIBIT ES-27. Comparison Of Monthly Cost/MM
Integrated Vs Non-Integrated IRN

Page ES-57

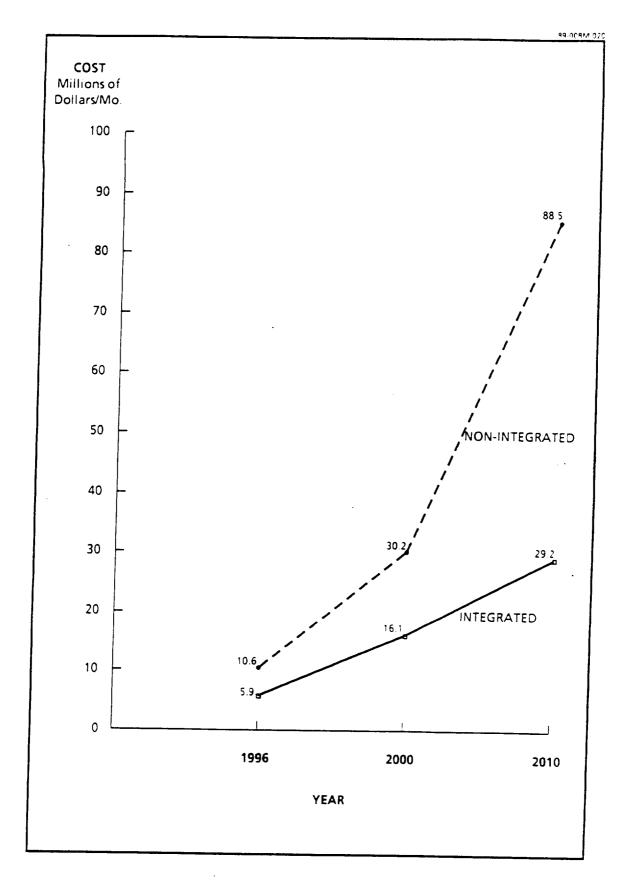


EXHIBIT ES-28. Comparison Of Monthly IRN Circuit Cost
Integrated Vs Non-Integrated IRN

APPENDIX A

LIST OF ABBREVIATIONS

All abbreviations are defined when they first appear in the text. Those abbreviations that are used more than once in the text are listed and defined here.

ABBREVIATION MEANING

ARC Ames Research Center

ARPANET Advanced Research Projects Agency Network

BARRNET Bay Area (No. California) Regional Research Network

BBN Bolt, Baranek and Newman
BITNET Before Its Time Network

CAN Campus Area Network

CICNET Committee on Institutional Cooperation Network

CRA Computer Research Applications
CRN Computer Research Network

CSNET Computer + Science Network

CTSS Cray Time Sharing System

DARPA Defense Advanced Research Projects Agency

DCA Defense Communications Agency

DDN Defense Data Network

DDN/PMO DDN Program Management Office

DECNET Digital Equipment Corporation (DEC) Communications

Software Products

DOD Department of Defense
DOE Department of Energy

DRI Defense Research Internet

EDUCOM Non-profit consortium of institutions of higher

education.

ER Energy Research

ESNET Energy Science Network

FCCSET Federal Coordinating Council for Science, Engineering &

Technology

FRICC Federal Research Internet Coordinating Committee

GSFC Goddard Space Flight Center

(CONTINUED)

ABBREVIATION MEANING

HEP High Energy Physics

HEPNET High Energy Physics Network

IN International Network

IPTO Information Processing Techniques Office

IRN Integrated Research Network

ISO International Standards Organization

JPL Jet Propulsion Laboratory

JSC Johnson Space Center

JVNC John von Neumann Center

JVNCNET John von Neumann National Supercomputer Center Network

KSP Kennedy Space Center
LAN Local Area Network

LEP3NET LEP = an accelerator at Cern, 3 = experiment number

MAN Metropolitan Area Network

MERIT Membership consortium of Michigan universities

MFE Magnetic Fusion Energy

MFENET Magnetic Fusion Energy Network

MIDNET Membership consoritum of midwestern universities

MM Megabits Per Second Mile - The movement of one megabit

per second one mile

MRNET Minnesota Regional Network
MSFC Marshall Space Flight Center

NASA National Aeronautics & Space Administration

NASCOM NASA's communication network (Goddard)

NASNET Numerical Aerodynamics Simulation Network

NASNET Numerical Aerodynamics Simulation Network
NCAR National Center for Atmospheric Research

NCSA National Center for Supercomputer Applications

NCSANET National Center for Supercomputing Applications Network

NIC Network Information Center
NIH National Institutes of Health

NIST National Institute of Standards & Technology

NJE/NJI Network Job Entry/Network Job Interface

(CONTINUED)

ABBREVIATION MEANING

NMFECC	National	Magnetic	Fusion	Energy	Computer	Center
--------	----------	----------	--------	--------	----------	--------

NN National Network

NNT National Network Test Bed

NOAA National Oceanic & Atmospheric Administration

NOC Network Operations Center

NORTHWESTNET Membership consortium in Northwest

NRC National Research Council
NRI National Research Initiatives
NRN National Research Network

NRNRC National Research Network Review Committee

NSECC NASA Space & Earth Sciences Computing Center

NSF National Science Foundation

NSFNET National Science Foundation Network

NSI NASA Science Internet
NSN NASA Science Network
NSP Non Standard Protocols

NTIA National Telecommunications & Information Administration

NTTF Networking & Telecommunications Task Force (EDUCOM)

NYSERNET New York State Education and Research Network (Cornell)

OARNET Ohio Academic Resources Network

OASC Office of Advance Scientific Computing (NSF)

OPMODEL DOE Operational Model Network

OSI Open Systems Interconnect

OSSA Office of Space Science & Applications

OSTP Office of Science & Technology Policy (White House)
PSCAA Pittsburgh Supercomputer Center Academic Affiliates
PSCN Program Support Communications Network (MSFC)

PSCNET. Pittsburgh Supercomputing Center Network

PSN Public Switched Network

RIB Research Interagency Backbone
RIG Research Interagency Gateways

RN Regional Network

(CONTINUED)

ABBREVIATION MEANING

SCD Scientific Computing Disvision (NCAR)

SCS Scientific Computing Staff (DOE/Office Of Energy

Research)

SDCS San Diego Supercomputer Center

SDSCNET San Diego Supercomputer Center Network

SESQUINET Texas Sesquicentennial Network

SN State Network

SPAN Space Physics Analysis Network

SURANET Southeastern Universities Research Association Network

TCP/IP Transmission Control Protocol/Internet Protocol

THENET Texas Higher Education Network

USAN University Satellite Network

WESTNET Network of five western states: AZ, CO, NM, UT, and WY

WN Worldwide Network

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A HILLE AND SUBTILE U.S. Computer Research Networks: Current and Future 6. AUTHORIS) D. Kratochvil, D. Sood, and A. Verostko 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSIES) Contel Federal Systems 15000 Conference Center Drive Chantilly, VA 22021-3808 8. SPONSORHIGIMONITORING AGENCY NAMES(S) AND ADDRESSIES) National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191 11. SUPPLEMENTARY NOTES Project Manager, James E. Hollansworth, Space Electronics Division, NASA Lewis Research Center, (216) 433-3458. 122. DISTRIBUTIONIAVAILABILITY STATEMENT Publicly Available Subject Categories - 17 and 32 123. ABSTRACT (Maximum 200 worse) The current and future telecommunications overview of capacit and connectivity requirements of the United States domestic research and development (R & D) community are identified. Starting with 1989 as the base year, projection are made for the years 1996 2000, and 2010. It is known, that it is more cost effective to implement researchers requirements as an integrated network rather than a piece meal basis, as is the case today. 14. SUBJECT TERMS U.S. Domestics Computer Research Networks 15. NUMBER OF 1. SECURITY CLASSIFICATION OF MEDITAL OF MEDITAL CLASSIFICATION OF MEDITAL CLASSIF	Davis Highway, Suite 1204, Arlington, VA 22202 1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND D	ATES COVERED
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